APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 2112-2388 VOL. 6, NO. 7 JULY 1953

GENERAL

Theoretical and Experimental Methods.. 315
Mechanics (Dynamics, Statics, Kinematics) 319

MECHANICS OF SOLIDS

Gyroscopics, Governors, Servos..... 320
Vibrations, Balancing..... 321
Wave Motion, Impact..... 323
Elasticity Theory..... 325
Experimental Stress Analysis..... 325
Rods, Beams, Shafts, Springs, Cables, etc. 327
Plates, Disks, Shells, Membranes..... 327
Buckling Problems..... 328
Structures..... 328
Rheology (Plastic, Viscoplastic Flow).... 330
Failure, Mechanics of Solid State..... 331
Material Test Techniques..... 333
Mechanical Properties of Specific Materials..... 333
Mechanics of Forming and Cutting..... 335

MECHANICS OF FLUIDS

Hydraulics; Cavitation; Transport..... 336
Incompressible Flow: Laminar; Viscous.. 338
Compressible Flow, Gas Dynamics..... 340
Turbulence, Boundary Layer, etc..... 341
Aerodynamics of Flight; Wind Forces.. 342
Aeroelasticity (Flutter, Divergence, etc.). 343
Propellers, Fans, Turbines, Pumps, etc... 344
Flow and Flight Test Techniques..... 345

HEAT

Thermodynamics..... 346
Heat and Mass Transfer..... 347

MISCELLANEOUS

Acoustics..... 349
Ballistics, Detonics (Explosions)..... 349
Soil Mechanics, Seepage..... 350
Micromeritics..... 350
Geophysics, Meteorology, Oceanography..... 350
Lubrication; Bearings; Wear..... 351
Marine Engineering Problems..... 352

Communications, 315

Vibration Damping, R. Plunkett, 313

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APPLIED MECHANICS REVIEWS

VOL. 6, NO. 7 MARTIN GOLAND Editor JULY 1953

VIBRATION DAMPING

ROBERT PLUNKETT

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VIBRATION damping is the reduction of the response of a mechanical system to a vibratory force; this is done by increasing the mechanical impedance of the system, by energy dissipation, or by tuned attachments. The term is also applied to vibration isolation, which is the reduction in efficiency of vibration energy transmission by changing mechanical impedance. Energy dissipation can be increased by: 1. Vibration dampers; 2. Connection damping; 3. Material damping.

The theory and design of vibration dampers for linear systems have been well explored and are now incorporated in the usual texts in vibrations. The extension to nonlinear systems and to interaction of systems at frequencies above the lowest resonances is relatively meager, primarily because of the complexity of the analysis.

Connection damping, which involves dissipation by relative movement of machine parts, is a relatively new approach for deliberate design. It is particularly effective at higher or acoustic frequencies. Little work has been reported in this field, but it is known that it is being actively followed in various commercial laboratories.

The literature on material damping, both theory and measurement, is overwhelming in its scope and no attempt is made here to cover it in detail. The theoretical work is now leading to methods whereby metallurgists can design high-damping alloys. The measurement work is leading to a better understanding of the effect of stress level and stress history on damping.

The design of vibration isolators effective at low frequencies has been reduced almost to the handbook level by recent compilations. There is still a great deal to be learned about the physical properties of elastomers and other materials which furnish the active components of these isolators.

The major immediate problem in the field of vibration reduction is the extension of rational design methods to higher frequencies, primarily the lower audio range. Associated with this are the analysis and development of what has here been termed connection damping. One of the retarding factors in this work has been the lack of simple instrumentation that will give reliable, consistent results.

1 VIBRATION DAMPERS

Vibration dampers may be rather narrowly defined as devices which consist of a mass coupled to a vibrating structure by a member which allows relative motion between the two. The relative motion enables the coupling member to change the natural frequency of the system, to dissipate energy, or both. Except in the case of synchronous machines, a change in natural frequency will not limit the vibration to acceptable levels, which means that the undamped absorber (1, 2, 3, 12)[1] is little used.

The exception to this is the pendulum absorber which does not permit the torsional natural frequency of rotors to be a given multiple of the rotating speed. This has seen wide application in internal-combustion engines since its first application in this country by Taylor (4). Zdanowich and Wilson (5) give a good description of practice previous to World War II. An SAE wartime symposium (6) brought this up to 1945 with some interesting articles on commercial experience. Harker (7) gives charts for the use of practical designers; Anderson and Soroka (8) show how to use electrical analog computers to save design time. Bevaux (9) gives some recent applications; Meyer and Saldin (10) show an interesting application to turbine buckets; and Reed (11) indicates the possibility of applying the principle to nonrotating machinery.

The damped tuned vibration absorber is mainly applicable for a rather limited frequency range. The pioneer papers were by Ormondroyd and Den Hartog (12, 13). Zdanowich (14) gives some more recent applications to practical problems in torsional vibration, as does the SAE symposium (6). Brock (15, 16) discusses optimum tuning, and Johnson (17) discusses admittance methods of design. Sauer and Garland (18) indicate useful performance over a wide frequency range when the excitation is caused by machinery unbalance. Granholm (19) gives an interesting analysis of the application to damped structures, and Speight (20) to electric conductors.

The untuned friction or Lanchaster damper does not have the same frequency range limitation, but is not as efficient at a given frequency (1, 2, 3, 13). Wente and Mueller (21) show practical application to movie projectors, Henderson (22) to fans, and Hahn (23) to machine tools.

Damping by impact has been little considered since some pioneer work by Paget (24). Lieber and Jensen (25) give theoretical analysis of impact damping, and Hamilton Standard has used it for aircraft propellers (26). Erlikh (27) shows an application to boring tools and discusses qualitatively the effect of mass ratio.

[1] Numbers in parentheses refer to the Bibliography at end of paper.

Electrical damping has hardly been used except for instrumentation such as in galvanometers and accelerometers. Two patents were issued in the 1920's, one using feedback (28) and one using electro-magnetic damping (29). A recent thesis by Ramsay (30) indicates that eddy current damping is impractical because it is too small with reasonable magnetic flux densities.

A very extensive listing of patents is given by Leavitt (31), covering all the afore-mentioned methods.

2 CONNECTION DAMPING

Vibration dampers depend on an added separate mass to furnish relative motion. Energy dissipation may also be achieved by relative movement between existing parts of a system. As with vibration dampers, optimum damping is also a problem here; Young (32) gives an interesting analysis of a classical problem closely related to this one, showing the adverse effects of overdamping.

Pian and Hallowell (33) give an analysis, confirmed by experiment, of the laminated or Muller beam; the experimental results are only for low frequencies. Manson and his co-workers (34, 35, 36) report on the extensive program of the NACA on turbine blade damping, with the main emphasis on damping by friction in the blade-to-wheel connection.

Shannon's (37) pioneer work in crankshaft damping by journals is extended by Draminsky (38) to give a better analysis of this important source of torsional damping in internal-combustion engines. Very little is reported in the literature on damping by coatings or paint. Geiger (39) gives a discussion of some results at acoustic frequencies; Slavik and Nemec (40) give the vibration damping and sound attenuation as a function of thickness with some particular materials used as paint.

3 MATERIAL DAMPING

In many cases material damping is the only thing that saves machinery from serious vibration effects. Since it is not often deliberately a matter of vibration design, no attempt is made to fully cover this very important subject here. There are several recent bibliographies available (41, 42, 43, 44) which cover the important papers on the theory and measurement of material damping. Marin and Stulen (45) have pointed out the importance of damping in choosing materials for fatigue strength. Lazan (46) has done some very interesting work recently on the measurement of material damping at high stresses and its correlation with stress history. Lazan (47) also discusses the influence of material damping on design calculations. Klotter's recent book (48) also discusses the influence of material damping on design, as well as giving the basic theory of vibration dampers.

4 VIBRATION ISOLATION

Two recent publications (49, 50) have made the task of this reviewer in discussing vibration isolation very easy. They give an up-to-date picture of present practice in design and many practical hints in the applications of this design. Geiger, et al. (50), have a particularly extensive bibliography. The more important recent references include a paper by Mindlin (54) on a theoretical analysis of shock isolation, a series by Haringx (55) on the behavior of springs and rubber rods with particular reference to buckling, and a series in the *Journal of Applied Physics* (56) on the properties of rubber. The action of resilient mounts at audiofrequencies is covered experimentally by Muster (51) and theoretically by Harrison and Sykes (52), but little has yet been published on the effects of foundation resilience or lack of stiffness in the mounted member.

Himelblau (53) has discussed this from the simplified approach of considering the foundation to be a one-degree-of-freedom system.

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Communications

To our readers:

We wish to amplify the number of reviewers who can read the Italian and Russian technical literature. The Editors would very much appreciate suggestions from our readers, giving the names of persons whom we should approach. The Editors

Concerning AMR 5, Rev. 2923 (October 1952) and Annual Author Index, AMR 6, No. 1, Section 2 (January 1953):

The author's name should read Bouasse, H.

Theoretical and Experimental Methods

(See also Revs. 2173, 2351)

2112. **MacDonald, W. H., III, Richardson, J. M., and Rosenberry, L. P., Representation of nonlinear field functions by Thiele semi-invariants,** *Quart. appl. Math.* **10**, 3, 284–289, Oct. 1952.

A method is given of evaluating certain integrals of nonlinear field dependent variables which possess the property of space localization of their gradients. For example, in determining the temperature $T(x)$ across a flame front in one-dimensional flame propagation, one must evaluate a moment integral of the form

$$-\infty \int^{\infty} e^{itx} I^s I_x \, dx = \varphi_s(t)$$

where

$$I(x) = T(x) - (1/2) \cdot [T(x_1) - T(x_2)]$$
$$= (i/2\pi) \, -\infty \int^{\infty} e^{-itx} t^{-1} \cdot \varphi(t) dt$$

The evaluation of the integral $\varphi_s(t)$ is carried out by replacing $T(x)$ by a set of dependent variables k which correspond to the Thiele semi-invariants of T_x. $\varphi(t)$ is, then, the characteristic function of T_x. Solutions are obtained for those functions T_x which also possess $\varphi(t)$ as Fourier transforms. The solution is obtained in the form

$$\varphi_s(t) = \Sigma_{\nu=0}^{\infty} \alpha_\nu t^\nu / \nu!$$

where the α_ν are determined as Taylor series in the k_ν.

The treatment of the equations of hydrodynamics by the moment transformation involves integrals in which the integrand includes various combinations of the gradient of a dependent variable and some other variable. The foregoing treatment is, therefore, generalized to the case where I is a generalized vector in a space of n dimensions. G. W. Evans, II, USA

2113. **Varnum, E. C., Circular nomogram theory and construction technique,** Prod. Engng., Annual Handbook of Prod. Design for 1953, F28–F30.

Basic properties of circular nomograms are only briefly mentioned, while construction of scales is discussed in great detail. As an example, a nomogram for the maximum slope angle of cycloidal cams is presented with description of all steps involved in the design. G. Rudinger, USA

2114. **Culver, R., The use of extrapolation techniques with electrical network analogue solutions,** *Brit. J. appl. Phys.* **3**, 12, 376–378, Dec. 1952.

The techniques described are quite useful for refining experimental data obtained from procedures based on finite difference approximations and have wider application than the title indicates. Having read the title, however, the reader who is not familiar with this application of networks expects some elaboration on the form of the network equations and a brief description of the electrical finite-difference analogy.

The question treated is the following: Let a problem concerning a continuum be approximated by a finite difference computation using n_1 grids or sections. Let a second calculation be made using n_2 grids, $n_2 > n_1$, what answer can be expected if an infinite number of grids are used? The author gives two formulas, one for the case when two sizes of grids are used, the other when three are used.

In Eq. [3] the h_1^2 factor should be n_1^2. H. M. Trent, USA

2115. **Vaughan, D. C., Relaxation methods. A three-dimensional mechanical analogy,** *Quart. J. Mech. appl. Math.* **5**, part 4, 462–465, Dec. 1952.

An analogy is established between the approximate mathematical solution to any three-dimensional finite difference equation, obtained by relaxation methods, and the deflections, in an arbitrary chosen direction, of the nodes of a corresponding, suitably loaded and tensioned, weightless, elastic three-dimensional net.

The analogy is valid for any form of space lattice, but three regular forms are of particular use.

From author's summary by M. V. Wilkes, England

2116. Bickley, W. G., Comrie, L. J., Miller, J. C. P., Sadler, D. H., and Thompson, A. J., Bessel functions. Part II. Functions of positive integer order, Brit. Assn. Advancement Sci., Math. Tables, vol. X, Cambridge University Press, 1952, xl + 255 pp. £3. $11.

2117. Dlin, A. M., Mathematical statistics in technics [Matematicheskaya statistika v tekhnike], Moscow, Gosud. Izd. Sovetskaya Nauka, 1951, 292 pp.

Book is written for students in Russian technical high schools, but it also presents a valuable handbook for use in practice. Illustrated by many examples, the work gives, in its 12 chapters, a clear and vivid presentation to a reader familiar with the most important statistical methods and their application in industrial production. Although based on mathematical grounds, the book does not explain mathematics for its own sake, as often occurs in books of this kind, but is intended first of all for practical purposes.

Giving a short summary of statistical methods and their usefulness in solving industrial problems, author proceeds to fundamental concept of distribution and investigates significance of usual characteristics. Third chapter contains fundamentals of the calculus of probabilities explained in accordance with the requirements of statistics; the fourth main part studies typical frequency curves. Discussion and use of the methods of least squares and of sliding means follow. The sixth chapter, devoted to study of samples, is very important, and the seventh main section deals with error analysis by means of statistics.

Then come considerations about control of industrial production. Chapter 11 discusses analysis of variance, while the final section explains theory of correlation and its use in quality control. Book ends with statistical tables and formulas for practical computations.

We recommend the work to engineers both as a textbook and as a handbook for daily use. V. Vodička, Czechoslovakia

2118. Zemany, P. D., Free molecular flow in the sample inlet to the mass spectrometer, *J. appl. Phys.* **23,** 8, 924–927, Aug. 1952.

Free molecule flow in a mass spectrometer leak is verified by demonstrating agreement between experimental measurements with a General Electric analytical mass spectrometer and predictions of the well-known effusive flow-rate formula. Conditions for molecular leak flow are stated in terms of leak diameter, flow rates, and sample pressure. It is found that leaks of the type detected by the helium leak detector are usually characterized by viscous (rather than free molecule) flow and, hence, use of such a light probe gas is of no advantage; rather, heavier argon is proposed to give greater sensitivity. Decrease of pressure in the sample chamber is shown to affect fragmentation patterns and sensitivities of the mass spectrometer. It is, therefore, recommended that these quantities "be reported in some more fundamental terms, such as flow rates, or fractional collection efficiency of the spectrometer." Reviewer believes this paper contributes to knowledge of the use of mass spectrometers and methods of interpreting results. A. J. Eggers, Jr., USA

2119. Wenzl, F., Numerical solution of algebraic equations (in German), *S.-B. math.-nat. Kl. bay. Akad. Wiss.* **1951,** 81–111, 1952.

A method is described for the solution of algebraic equations of fourth degree which depends on factorization into two second-degree factors [cf. the method of B. Friedman, AMR **4,** Rev. 30]. Conditions of convergence are obtained. The method is extended to equations of higher degree.

Courtesy of Mathematical Reviews E. Frank, USA

2120. Rapoport, I. M., A new method of approximate integration of ordinary linear differential equations (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85,** 955–958, 1952.

Author considers an nth order system of linear differential equations expressed in the form $X'(t) = A(t)X(t)$, in which $A(t)$ is an nth-order known matrix, and $X(t)$ is an nth-order matrix with unknown elements. This equation is solved by a process of matrix iteration which, with suitable limitations, is shown to converge uniformly in some interval of the t-axis. The method is illustrated for the case $n = 2$ by a simple example.

Courtesy of Mathematical Reviews W. E. Milne, USA

2121. Guest, P. G., Curve-fitting by the method of grouping, *Austral. J. sci. Res. (A)* **5,** 238–257, 1952.

This follows a previous article [*Ann. math. Statistics* 22, 537–548, 1951] except that here the author considers methods appropriate when the x's are not equally spaced. In this case, the usual orthogonal polynomial tables cannot be used; hence, a fairly efficient grouping method is desirable. The y's are grouped so as to maximize the efficiencies of the estimated regression coefficients when the x's are equally spaced. Some investigations have shown that these efficiencies are not reduced materially for unequally spaced x's unless many observations are clustered at one end of the range. Methods of grouping are presented for polynomials through the fourth degree and number of observations $n = 10(1)100$. The efficiencies for equally spaced x's are given for large n and specifically for $n = 20, 36, 48, 60, 75, 80, 95, 100$. An example is presented for $n = 16$, with unequally spaced x's. Approximate formulas for the standard errors of the regression coefficients are also presented.

Courtesy of Mathematical Reviews R. L. Anderson, USA

2122. Borsuk, K., Analytic geometry in n dimensions [Geometria analityczna w n wymiarach], Mongrafie matematyczne, Spółdzielnia wydawnicza "Czytelnik," 1950, 448 pp.

Engineers usually cannot fully appreciate the great significance of analytic geometry in n dimensions for various branches of technical science, although 100 years ago Jacobi told of the intimate relation between dynamics and geometry of curved spaces. Famous investigations of Riemann, Einstein, Synge, and others showed the value of Jacobi's ideas, and today no serious study of such an important subject as variational methods of mechanics with all technical applications can be accomplished without knowledge of vector and tensor calculus, which presupposes familiarity with analytic geometry of multi-dimensional spaces. There are not many useful books on this subject, and Professor Borsuk's work certainly is one of the best of this kind in the world's literature.

Book is written as a textbook for universities; nevertheless, many of its sections are of immediate importance for engineers. In addition to detailed knowledge of analytic geometry in poly-dimensional spaces, this work gives to technicians an excellent introduction to the theory of abstract spaces, which is becoming more and more significant in various branches of applied mathematics.

Book is divided into three main parts. First comes a detailed theory of Cartesian spaces; the next section deals with projective varieties; and the last main part concerns analytic geometry in complex spaces. Author is one of the greatest specialists of our era, and the book contains numerous results of his own research work.

We warmly recommend this excellent work to mathematicians and to engineers who are interested in applied mathematics. Of course, initial concentration is somewhat difficult, but results abundantly reward this effort.

V. Vodička, Czechoslovakia

2123. **Luke, Y. L., Mechanical quadrature near a singularity,** *Math. Tables and other aids to Computation* **6,** 215–219, 1952.

2124. **Jacobsen, L. S., On a general method of solving second-order ordinary differential equations by phase-plane displacements,** *J. appl. Mech.* **19,** 4, 543–553, Dec. 1952.

Author gives a graphical method for finding solutions of differential equations of the form $\ddot{x} + kx + g(x,\dot{x},t) = 0$, where k is a constant. Various examples of the vibration of linear and nonlinear systems are worked out. A. Devinatz, USA

2125. **Fox, L., and Goodwin, E. T., The numerical solution of non-singular linear integral equations,** *Phil. Trans. roy. Soc. Lond.* (A) **245,** 902, 501–534, Feb. 17, 1953.

Various methods for numerical solution of linear integral equations (I.E.) are developed. Some are related to the classical procedures of iterations and successive approximations; most of them, however, are based on concepts of the modern theory of finite differences and convey new thoughts. Direct application of the methods is restricted to I.E.'s of nonsingular kernels and solutions, but might be extended, however, beyond these limitations in so far as many singular I.E.'s may be transformed into nonsingular shape by analytical processes.

Attention is concentrated on the Fredholm I.E.'s of first and second kind

$$ {}_a\int^b k(x,y)\, f(y)\, dy = g(x) \qquad [1]$$

$$ {}_a\int^b k(x,y)\, f(y)\, dy = f(x) + g(x) \qquad [2]$$

the Fredholm eigenvalue problem

$$ \lambda\, {}_a\int^b k(x,y)\, f(y)\, dy = f(x) \qquad [3]$$

and the Volterra I.E.'s of first and second kind

$$ {}_a\int^x k(x,y)\, f(y)\, dy = g(x) \qquad [4]$$

$$ {}_a\int^x k(x,y)\, f(y)\, dy = f(x) + g(x) \qquad [5]$$

Main principle of solution is the replacement of the integral by a finite difference approximation of the type

$$ (1/h)\, {}_a\int^{a+nh} f(x)\, dx = 1/2f_0 + f_1 + \ldots + f_{n-1} + 1/2f_n + \Delta $$

where $f_0 = f(a)$, $f_r = f(a + rh)$, and Δ = difference correction, and subsequent development of I.E. into a set of simultaneous algebraic equations. Process is successful in case of Eqs. [2], [3], [4], [5]. Method is not successful in case [1], which is, of course, not surprising at all in view of the analytical behavior of I.E. [1]. Calculations take specifically simple form in I.E.'s [4] and [5] because of the triangular shape of the matrix of the equivalent linear equation system.

Examples contained in paper include

$$ (4/\pi)\, {}_0\int^{\pi/2} \cos(x - y) f(y)\, dy = (2/\pi)\cos x + f(x) $$

(with solutions: $f(x) = \sin x$), and

$$ \lambda\, {}_0\int^{\pi/2} \sin(x + y)\, f(y)\, dy = f(x) $$

(with solutions: $f(x) = \cos x \pm \sin x$, for $\lambda^{-1} = 1/2 \pm 1/4\pi$).

Authors conclude that their theory may be extended to nonlinear I.E.'s as well as to integrodifferential equations. Reviewer adds that latter perspective would be very desirable in view of the importance of integrodifferential equations in today's problems of aeroelasticity and other subjects. M. A. Dengler, USA

2126. **Mitchell, J., On the spherical convergence of multiple Fourier series,** *Amer. J. Math.* **73,** 211–226, 1951; correction, **75,** 57–59, 1953.

This paper gives a sufficient condition for the convergence, almost everywhere, of multiple Fourier series summed over spheres. If $\{a_{n_1 \ldots n_k}\}$ are the Fourier coefficients, the condition is

$$ \Sigma(n_1^2 + \ldots + n_k^2)^p |a_{n_1 \ldots n_k}|^2 < \infty $$

where $p = \frac{1}{3}$ for $k = 2$, $p = k/4$ for $k \geqq 4$, and the sequence $(n_1^2 + n_2^2 + n_3^2)^p$ is replaced by

$$ (n_1^2 + n_2^2 + n_3^2)^{2/3} (\log(n_1^2 + n_2^2 + n_3^2))^{5/3} $$

if $k = 3$. The proof is based on an estimate of the integral

$$ -\pi\int^{\pi} \ldots -\pi\int^{\pi} |\varphi_R(\alpha - x)| dx_1 \ldots dx_k $$

where

$$ \varphi_R(\alpha - x) = (2\pi)^{-k} \sum_{\nu \leqq R} \exp(n_1(\alpha_1 - x_1) + \ldots + n_k(\alpha_k - x_k)) $$

and $\nu^2 = n_1^2 + \ldots + n_k^2$. Once this estimate has been made, the argument proceeds on classical lines.

Courtesy of Mathematical Reviews K. Chandrasekharan, India

2127. **Gallissot, F., Infinitesimal transformations and integrations of the differential equations of mechanics** (in French), *C. R. Acad. Sci. Paris* **235,** 1277–1278, 1952.

Let V_{2n+1} be a manifold of dimension $2n + 1$, Ω an exterior quadratic differential form of rank $2n$, and Σ the system of differential equations associated to Ω. Suppose $d\Omega = 0$. Then to every infinitesimal transformation under which Ω is invariant corresponds a first integral of Σ, and vice versa. If $X^1, \ldots, X^n$ are n infinitesimal transformations under which Ω is invariant and are two-by-two in involution, then Σ can be integrated by quadratures and there are n closed Pfaffian forms $\pi^1, \ldots, \pi^n$, so that $\Omega = \Sigma_{\alpha=1}^n \pi^\alpha \wedge \pi_\alpha$. The results have applications to analytical dynamics.

Courtesy of Mathematical Reviews S. Chern, USA

2128. **Schmidt, A., Linear partial differential equations with constant coefficients** (in German), *J. reine angew. Math.* **189,** 160–167, 1951.

E. Lammel, in an unpublished lecture, using a generalization of the relationship between analytic function theory and plane potential theory, showed that the partial-differential equation with constant coefficients

$$ a_0 \frac{\partial^n u}{\partial x^n} + a_1 \frac{\partial^n u}{\partial x^{n-1} \partial y} + \ldots + a_n \frac{\partial^n u}{\partial y^n} = 0 \qquad [1]$$

has the general solution

$$ u = \sum_{j=1}^{r} \{ \varphi_{j1}(x + \lambda_j y) + y\varphi_{j2}(x + \lambda_j y) + \ldots + y^{m_j - 1} \varphi_{jm_j}(x + \lambda_j y) \} \qquad [2]$$

where the λ_j are the roots of the equation

$$ a_0 + a_1\lambda + \ldots + a_n\lambda^n = 0 \qquad [3]$$

and m_j their multiplicities. Lammel required both u and the otherwise arbitrary functions φ_{jh} to be analytic. The present paper contains a direct proof of the fact that [2] is the general solution of [1], it being assumed only that all partial derivatives of the nth order of u are continuous; the functions φ_{jh} corresponding to non-real roots of [3] turn out to be analytic, while those corresponding to real roots of [3] turn out to be n times continuously partially differentiable. An extension of the theorem to systems with constant coefficients $\partial v_k/\partial t + \Sigma_{l=1}^n a_{kl} \partial v_l/\partial x = 0$ is also given.

Courtesy of Mathematical Reviews J. B. Diaz, USA

2129. Ladizhenskaya, O., On integrals of hyperbolic equations (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **79,** 925–927, 1951.

Author considers solutions of the hyperbolic equation

$$u_{tt} = \sum_{i,j=1}^{m} \frac{\partial}{\partial x_i}\left(a_{ij}(x)\frac{\partial u}{\partial x_j}\right) - a(x)u \qquad [*]$$

subject to the boundary conditions $(\alpha u + \beta \partial u/\partial N)_S = 0$, where S is a smooth closed surface in n-dimensional space bounding a domain Ω, and α and β are prescribed functions. Certain integrals $\int_\Omega \omega_k(u, v)d\Omega + \int_S \omega_{k-1}(u, v)\,dS$, where $\omega_k(u, v)$ is a bilinear expression involving derivatives to the kth order of u and v, and where u and v are solutions of [*] satisfying the boundary conditions, are discussed. A collection of such integrals is called complete if estimates for a certain integral $H_k(u)$ involving squares of the derivatives (to the kth order) of u can be obtained in terms of this collection. The problem of finding complete systems of positive integrals for arbitrary order k is solved.

Courtesy of Mathematical Reviews M. H. Protter, USA

2130. Èidus, D. M., On the solution of boundary problems by the method of finite differences (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **83,** 191–194, 1952.

The Dirichlet boundary-value problem has been dealt with by the method of finite differences by L. A. Lyusternik [*Mat. sbornik* **33**, 173–201, 1926]; I. G. Petrovskiĭ [*Usp. matem. Nauk* **8,** 161–170, 1941]; R. Courant, K. Friedrichs, and H. Lewy [*Math. Ann.* **100**, 32–74, 1928]. In the present paper, other boundary-value problems for the elliptic equation

$$Lu \equiv \sum_{i,j=1}^{m} \frac{\partial}{\partial x_i}\left(a_{ij}(x)\frac{\partial u(x)}{\partial x_j}\right) = f(x), \quad a_{ij} = a_{ji}$$

are treated by the method of finite differences. Particular attention is given to the boundary-value problem where the boundary condition is

$$Pu = \sum_{i,j=1}^{m} a_{ij}\frac{\partial u}{\partial x_i}\cos(\nu, x_j) = 0$$

It is remarked that a similar procedure is applicable to mixed boundary problems and eigenvalue problems for the same operator L.

Courtesy of Mathematical Reviews J. B. Diaz, USA

2131. Stebakov, S. A., Qualitative investigation of the system $\dot{x} = P(x, y)$, $\dot{y} = Q(x, y)$ by means of isoclines (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **82,** 677–680, 1952.

The autonomous system $x' = P(x, y)$, $y' = Q(x, y)$ $(' = d/dt)$ is considered in the neighborhood of an isolated singular point. By constructing certain polygonal paths and considering the direction field defined by the above system, it is shown that some qualitative results can be stated concerning the solution paths of the system near the singular point. The constructions do not seem to differ much from the standard ones used to prove the Poincaré-Bendixson theorem.

Courtesy of Mathematical Reviews E. A. Coddington, USA

2132. Ghizzetti, A., On a fundamental theorem of the theory of the Laplace transform (in Italian), *Cons. naz. Ric.* no. 352, 13 pp., 1953 = *R. C. Semin. Fac. Sci. Univ. Cagliari* **21,** no. 3–4, 1951.

Object of the investigation is the convolution theorem of the theory of the Laplace transform, which may be written as

$$L\{F(t) * G(t)\} = L\{F(t)\} \cdot L\{G(t)\}$$

where

$$F(t) * G(t) = {}_0\int^t F(t-u)\,G(u)\,du$$

and

$$L\{F(t)\} = f(s) = {}_0\int^\infty e^{-st} \cdot F(t)dt$$

A generalization of the theorem is presented and analyzed in the perspective of convergence and existence. Necessary and sufficient conditions to be imposed on the functions $F(t)$ and $G(t)$ are deduced. The analogies between the convolution theorem and the product theorems of the multiplication of infinite series are demonstrated. Among other interesting related questions the following one is carefully elaborated and answered: Given two functions $\varphi(t)$ and $\psi(t)$ in the interval $(0, \infty)$, assuming that they are summable in any partial interval $(0, T)$ with $T > 0$, and assuming, finally, that the integrals ${}_0\int^\infty \phi(t)\,dt$ and ${}_0\int^\infty \psi(t)\,dt$ are convergent, under what conditions does there result the convergence of the integral ${}_0\int^\infty \{\varphi(t) * \psi(t)\}dt$?

M. A. Dengler, USA

2133. Bertolini, F., The theorems of the Laplace transform of order $\alpha > -1$ (in Italian), *R. C. Accad. Sci. Fis. Mat. Napoli* (4) **18** (1951), 146–155, 1952 = *Cons. naz. Ricer. Publ. Ist. Appl. Calcolo* no. 316, 10 pp. 1951.

Let $F(t)$, defined for $t \geqq 0$, be summable in every finite subrange. A familiar property of the Laplace transformation is as follows: If the improper integral ${}_0\int^\infty \exp(-st)F(t)dt$ converges for $s = s_0$, then it also converges for any s of real part exceeding the real part of s_0. The analog of this theorem is here established for the Laplace transform based on the following summability concept for improper integrals: If $G(t)$ is summable in every finite range and $\alpha > -1$, then

$$\int_0^\tau G(t)\left(1 - \frac{t}{\tau}\right)^\alpha dt, \quad \tau > 0 \qquad [1]$$

is known to exist for almost all real τ. The improper integral of order α is defined as

$${}^{(\alpha)}\int_0^\infty G(t)dt = \lim_{\tau \to +\infty} \int_0^\tau G(t)\left(1 - \frac{t}{\tau}\right)^\alpha dt$$

provided the limit exists as $\tau \to +\infty$ over the set for which [1] exists. The generalized transformation

$${}^{(\alpha)}\int_0^\infty \exp(-st)F(t)dt$$

is now shown to enjoy the classical property mentioned above.

Courtesy of Mathematical Reviews I. J. Schoenberg, USA

2134. Meschkowski, H., Some extremum problems in the theory of conformal mapping (in German) *Ann. Acad. Sci. Fennicae.* (*A*) I *Math.-Phys.* no. 117, 12 pp., 1952.

Author discusses in detail familiar extremal characterizations of canonical-conformal mappings of a multiply connected domain, and develops representations of such mappings in terms of an ortho-normal system which are related to the representations by the kernel function.

Courtesy of Mathematical Reviews P. R. Garabedian, USA

2135. Albrecht, R., On a limit method of the theory of conformal transformations (in German), *ZAMM* **32,** 316–318, 1952.

In Koebe's proof of the Riemann mapping theorem [*J. reine*

angew. Math. **145**, 177–223, 1915], a sequence of functions is constructed whose limit is the function which maps a given simply connected region conformally on the unit circle. The author proposes replacing Koebe's functions by another class of functions for which the convergence will be more rapid, and using this procedure to approximate the mapping function. This class of functions includes, as special cases, the transformations suggested by Ringleb [AMR **3**, Rev. 1621], and by Heinhold [*S.-B. math.-nat. Kl. bay. Akad. Wiss.*, 203–222; **1948**].

Courtesy of Mathematical Reviews C. Saltzer, USA

✎2136. **Bieberbach, L., Conformal mapping,** New York, Chelsea Publ. Co., 1953, vi + 234 pp. $2.25.

This translation of the fourth German edition is clear, concise, and free of errors. Theory is carefully explained from elementary concepts through existence, uniqueness, distortion theorems. A few mappings are described in great detail and then used as illustrations. Engineers will profitably use book for its accurate exposition (with perhaps a minimum of mathematical shorthand) as a companion to works on applications and dictionaries of mappings. C. M. Ablow, USA

2137. **Wittich, H., On an extremum problem in the theory of conformal mapping** (in German), *Arch. Math.* **2**, 325–333, 1950.

Using the length-area principle, author discusses the problem of maximizing the modulus of a ring domain whose two boundary components include given points.

Courtesy of Mathematical Reviews P. R. Garabedian, USA

✎2138. **Chattelun, L., Vector calculus. Vol. I: Algebra, linear algebra and applications [Calcul vectoriel. Tome I. Algebre. Algebre lineaire. Applications]** (in French), Paris, Gauthier-Villars, 1952, viii + 605 pp. 5000 fr.

2139. **Buckel, W., General similarity of conformal transformations** (in German), *S.-B. math.-nat. Kl. bay. Akad. Wiss.* 1951, 163–189, 1952.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2113, 2155, 2320, 2333, 2344, 2347)

2140. **Gallissot, F., On a universal method for derivation of the equations of motion of mechanical systems** (in French), *C. R. Acad. Sci. Paris* **234**, 2148–2150, 1952.

2141. **Ziegler, H., On the concept of conservative systems** (in German), *Elemente Math.* **7**, 121–129, 1952.

Clarification of basic ideas on work and energy in elementary mechanics, with a discussion of generalized gyroscopic forces in Lagrange's equations. J. L. Synge, Ireland

2142. **Capon, R. S., Hamilton's principle in relation to nonholonomic mechanical systems,** *Quart. J. Mech. appl. Math.* **5**, part 4, 472–480, Dec. 1952.

Author discusses Hamilton's principle as applied to nonholonomic mechanical systems. H. Hertz has indicated (reference given in article) that, in some instances, the principle gives an infinity of solutions which are not correct. O. Holder suggested in another reference that the failure of the principle was due to an inadequacy of the mathematical representation of the constraints. The author concludes, from his discussion, that Holder's conclusion is in error and that the failure arises in the principle itself.

W. B. Stiles, USA

2143. **Szebehely, V. G., On the problem of three bodies in a plane,** *Math. Mag.* **26**, 2, 59–66, Nov./Dec. 1952.

Problem is expressible as a twelfth-order system of partial-differential equations which is usually reduced to a Hamiltonian system of lower order and, finally, to one of fourth order by using four integrals of motion of the center of gravity, a contact transformation, the energy integral, and eliminating the time. Author avoids the use of contact transformation by employing a new set of generalized coordinates. Problem is investigated fully for bodies of equal mass under the action of attracting forces proportional to cubes of distance. Some results will be verified in another paper. S. Kirkby, England

2144. **Le Corbeiller, P., and Yeung, Y.-W., Duality in mechanics,** *J. acoust. Soc. Amer.* **24**, 643–648, 1952.

The duality is that relating the equations of a mechanical system in terms of forces (Newton-d'Alembert) to that in terms of velocities (Firestone-Trent). In this relation, coordinate corresponds to momentum. The direct derivation of the second form, as well as the analogy with two electric systems (based on mesh or node analysis) is considered. The authors indicate the advantages of the simultaneous study of all four systems.

Courtesy of Mathematical Reviews P. Franklin, USA

2145. **Rund, H., The Hamiltonian function of general dynamical systems** (in German), *Arch. Math.* **3**, 207–215, 1952.

By a general dynamical system is meant one in which the kinetic energy is not necessarily a quadratic form in the components of the velocity vector. The author adopts methods of Finsler geometry, as recently developed by himself, and arrives at a generalized form of the Hamilton-Jacobi theory. Notions such as the canonical equations, the Hamilton function, the Hamilton-Jacobi differential equation, etc., are introduced and geometrically interpreted.

Courtesy of Mathematical Reviews S. Chern, USA

2146. **Stojanović, R. D., Differential equations of the movement of a rigid body in tensorial form** (Serbo-Croatian, with English summary), *Bull. Soc. Math. Phys. Serbie* **4**, 1–2, 43–49, 1952.

The equations are those appearing in Whittaker, "A treatise on the analytical dynamics . . . .," example on p. 44 [4th ed., Cambridge, 1927], in different notation and more explicit form. The author seems to regard the use of summation convention as sufficient for tensorial form. The separate terms of the equations are not tensors. A. W. Wundheiler, USA

✎2147. **Finzi, B., Theoretical mechanics. I.: Introduction to the theory. Kinematics. Statics [Meccanica razionale. Volumo primo: Teorie introductive, cinematica, statica], Seconda edizione** (in Italian), Bologna, Nicola Zanichelli Editore, 1950, xii + 343 pp. 2000 lire.

Second edition of an extensive, carefully composed, and well-written textbook. Vector and tensor calculus, not purely mathematically treated and with many applications, are given in an introduction (pp. 1–95). Kinematics follow (pp. 97–219) with its subdivisions: displacement, motion, velocity, acceleration (all for points, systems, and rigid bodies) and relativistic kinematics. The last part gives statics, for the point, the rigid body, and deformable systems, and ends with a chapter on virtual displacements. The book is mathematically satisfying and gives, moreover, many physical examples; it is an excellent textbook on the subject, both scientifically and pedagogically.

O. Bottema, Holland

2148. Finzi, B., Theoretical mechanics. II. Dynamics [Meccanica razionale. Volume secondo. Dinamica.] Seconda edizione (in Italian), Bologna, Nicola Zanichelli Editore, 1950, xi + 425 pp. 2000 lire.

The second volume has the same quality as the first. To give an impression of its contents, it deals, e.g., with the general theorems of dynamics, the principles of thermodynamics, the mechanics of relative motion, relativistic dynamics, units and dimension of physical quantities, Poinsot's motion of a rigid body, the "symbolic" equations of dynamics, d'Alembert's principle, stability of equilibrium, small vibrations, Maggi's equations for anholonomic systems, canonical equations, variation principles, dynamics of continuous systems, impact, statistical mechanics.

O. Bottema, Holland

2149. Eremeev, N. V., On the theory of mechanisms of variable structure (in Russian), *Uchen. Zap. mosk. Univ.* 154, *Mekhanika* **4,** 61–71, 1951.

This vague paper seems to be concerned with the fact that Grübler's expression $(3n - 2p)$ for the mobility of a plane linkage admits exceptions when the equations of the constraints happen to be dependent ("dwells" are a familiar example). The condition for this increased mobility is that the absolute and relative instant centers of any pair of links be collinear. This issue is at the basis of Artobolevskiĭ's concept of "class," which has already achieved textbook status in Russia. The purpose of the paper, therefore, is not clear. The author gives much emphasis to the well-known fact that increased mobility may be instantaneous (singular positions) or persistent. A. W. Wundheiler, USA

2150. Fricke, A., On a nonlinear integral equation of the theory of circular motion (in German), *Math. Nachr.* **8,** 185–192, 1952.

Let T be the periodic time when a particle of unit mass describes a circular orbit of radius R under a central force $f(r)$; and let T' be the time of fall from rest at distance R to the center under the same force. Then if the law of force is the inverse square, $T : T' = 4\sqrt{2}$ for any value of R. The question is to find whether $T : T'$ has a value independent of R for other laws of force. This comes to solving the integral equation

$$\int_0^R \frac{dr}{\sqrt{\left\{\int_r^R f(r')dr'\right\}}} = \lambda \sqrt{\left\{\frac{R}{f(R)}\right\}}$$

If $f(r)$ is integrable at the origin, this can be transformed into

$$\int_0^x \frac{y(u)du}{\sqrt{(x-u)}} = \lambda \sqrt{\left\{y(x)\int_0^x y(u)du\right\}} \qquad [A]$$

whereas if it is integrable at infinity

$$\int_x^\infty \frac{y(u)du}{\sqrt{(u-x)}} = \lambda \sqrt{\left\{y(x)\int_x^\infty y(u)du\right\}} \qquad [B]$$

The integral equation [A] has a continuous spectrum $\lambda > \sqrt{\pi}$, with solutions $y = x^\mu$ $(\mu > -1)$, whereas [B] has spectrum $0 < \lambda < \sqrt{\pi}$ with solutions $y = x^{-\mu}$ $(\mu < -1)$. If $\lambda = \sqrt{\pi}$, [B] has the solution $y = e^{-x}$.

Courtesy of Mathematical Reviews E. T. Copson, Scotland

2151. Tolle, O., On the dynamics of cam drives (in German), *Motortech. Z.* **13,** 12, 288–289, Dec. 1952.

A rotating cam displaces a linearly guided contact roller. The cam is driven by a force K of given strength and line of action. Angular position and angular velocity ω of cam are also given. Problem is to graphically find accelerations, inertia forces, and reactions. Author's solution is: (1) Cam is replaced by eccentric linkage according to angular position; (2) ω is considered as constant; K is substituted by unknown force K_ω with same line of action as K. Simultaneous determination of K_ω and solution of problem; (3) problem is solved for force $K - K_\omega$ and $\omega = 0$; solution is superposed on that of (2).

H. Bückner, Germany

2152. Chudakov, E. A., On the rational form of the steering linkage of an automobile (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **86,** 4, 669–671, Oct. 1952.

Due to tire lateral flexibility, the wheels of an automobile in a turn do not roll in their own planes. Equalization of the resulting lateral loads on the front tires is proposed as a rational basis for the design of the steering linkage. Theoretical (theory not given) and measured side loads are presented. Three different tie-rod lengths were used. Side loads approached equality as rod length increased. Conclusion is that steering linkage should be designed to bring tie-rod ends in approximate fore-and-aft alignment with steering knuckles. W. W. Soroka, USA

Gyroscopics, Governors, Servos

(See also Rev. 2382)

2153. Brock, P., Design of servo gear trains to minimize reflected inertia, Ann. Meet. ASME, New York, Dec. 1952, Paper 52—A-48, 8 pp.

A generalized method of minimizing reflected inertia of a servo gear train and a discussion of its application are presented. Two nomographs based on a simplification of the general case are included. These enable the designer to choose an optimum number of meshes in a train of a given over-all ratio and to choose the ratio of the individual meshes so as to minimize the inertia reflected by the gear train into the motor. The method is applicable primarily with instrument servos where the gear-train inertia represents an appreciable portion of the load.

From author's summary by T. J. Dolan, USA

2154. Kats, A. M., On the question of evaluation of the quadratic criterion of the quality of regulation (in Russian), *Prikl. Mat. Mekh.* **16,** 3, 362–364, May/June 1952.

Let $f(t)$ represent some regulated variable and $F(p)$ its p-multiplied Laplace transform. The integral

$$J = \int_0^\infty [f(t)]^2 dt = -(2\pi i)^{-1} \int_{-i\infty}^{i\infty} p^{-2} F(p) F(-p)\, dp$$

measures the quality of regulation of $f(t)$. Author writes $F(p)$ as the quotient of two polynomials, $F(p) = pP(p)/Q(p)$. Let

$$P(p)P(-p) = g_0 p^{2n-2} + g_1 p^{2n-4} + \ldots + g_{n-1}$$

and

$$Q(p) = a_0 p^n + a_1 p^{n-1} + \ldots + a_n$$

Author shows that $J = (-1)^{n-1} G/(2a_0 D)$, where D is the Hurwitz determinant of the polynomial $Q(p)$ and G is the same determinant with its first row $(a_1, a_3, a_5, \ldots)$ replaced by $(g_0, g_1, \ldots, g_{n-1})$.

R. E. Gaskell, USA

2155. Stoppelli, F., On gyroscopic phenomena in solids of arbitrary properties (in Italian), *R. C. Sem. Mat. Univ. Padova* 21, part I, 25–43, 1952.

Author shows that the gyroscopic phenomena of any rigid body, rotating with great initial angular velocity $\vec{\omega}_0 = r_0\mathbf{k}$ about axis a of the permanent stable rotation, and subject to a force having a

moment about a fixed point O in an arbitrary direction, depend neither upon this direction nor upon the body's properties.

From the relation $C\bar{r}_0\mathbf{k}_t = \mathbf{M}^*$ (where C is the principal moment of inertia, $\mathbf{M}^*$ moment of force $(Q'\,\mathbf{F})$, Q' is the orthogonal projection of Q on a, and $\bar{r}_0 = r_0 + [(M_a)\varphi/Cr]_{t=0}$), author derives the Euler angles to the infinitesimal quantities in order $1/r_0$. These values agree with those of the gyroscope, rotating with velocity $\bar{r}_0\mathbf{k}$, under the same moment $\mathbf{M}^*$.

The derived relations are applied to a weighted body. Because of the approximations, the motion is the regular precession.

Assuming that the projections of the force on fixed axes are the functions of $t, \theta, \psi, r, s_i(t)$ and $\dot{s}_i(t, r, \theta, \psi, s_i)$, the solutions can be applied to a free body. In this case the functions s_i are the coordinates of the body's mass center.

D. Rašković, Yugoslavia

Vibrations, Balancing

(See also Revs. 2175, 2220, 2313, 2370)

2156. **Slade, J. J., Jr., The elastic axes of a one-mass elastically supported system,** *Quart. appl. Math.* **10,** 3, 278–280, Oct. 1952.

Steady motion of an elastically supported rigid body subjected to the action of a rectilinear sinusoidal force generally consists of rectilinear and torsional oscillations with frequency equal to that of the exciting force. It is desired to determine the location of the exciting force so that torsional oscillations are suppressed or, at least, the amplitude of these oscillations is reduced to a minimum. Problem arises, for example, in connection with unbalanced machines on elastic foundations.

An axis with which the line vector, resulting from the vectors of the exciting force as well as of its moment, must coincide to satisfy the condition that torsional oscillations are suppressed is here called an elastic axis of the system. An axis of fixed direction with which the line vector must coincide to make the amplitude of torsional oscillations a minimum is called a quasi-elastic axis.

Present investigation deals with the general three-dimensional case of a rigid body that can move freely under general linear elastic constraints with linear damping. Exciter force is rigidly connected to the system, and only small oscillations are considered. After formulation of the linear vectorial equilibrium conditions for center of gravity of the body and for the moment, and by means of the exponential rate for solution of the equations, author discusses the conditions under which (1) rotational oscillations about a principal axis are suppressed, (2) rotational oscillations about two principal axes are simultaneously suppressed if the system is conservative. In general, the nonconservative system possesses no elastic axis. In this case, it is only possible to reduce the oscillations to a minimum.

W. Kochanowsky, Germany

2157. **Chenea, P. F., On the application of the impedance method to continuous systems,** Ann. Meet. ASME, New York, Dec. 1952, Paper 52—A-28, 4 pp.

The impedance concept (impedance = ratio of force to corresponding displacement) is extended to continuous systems governed by the one-dimensional wave equation. While the method does not solve any problems which cannot be handled by the classical approach, it is shown to offer distinct advantages in the analysis of free and forced longitudinal and torsional vibrations of stepped shafts. Engineers familiar with the analysis of electrical circuits and acoustical mechanisms, or of mechanical systems having concentrated elasticity mass and damping, will be able to use this material to extend their analytical method in a systematic way to include systems having distributed properties, including a continuous or abrupt space variation in density, elasticity, cross-sectional area, and damping.

Reviewer notes that author's Eq. (5) governing the impedance can be derived directly from his Eqs. (1) to (4) without introducing the change in impedance across an infinitesimal element.

L. E. Goodman, USA

2158. **Rosard, D. D., Natural frequencies of twisted cantilever beams,** Ann. Meet. ASME, New York, Dec. 1952, Paper 52—A-15, 4 pp.

Author studies the effect of twist of a cantilever beam on the natural frequencies of vibrations. Beams of various lengths and width-to-thickness ratios were welded to a heavy bedplate. By striking the beams with a hammer, vibrations were excited and their frequencies measured with a "Stroboconn" used in conjunction with a microphone. An analytical investigation of the effect of twist on the natural frequencies was also made. This was done by dividing the beam into ten sections of equal lengths and considering the mass of each section concentrated at its midpoint. Equations for the deflection, shear, moment, and slope were then obtained which could be solved by setting up an equivalent electrical network or by means of punched-card machines. It is pointed out that the effect of the twist follows the same simple law as that of other forms of coupled vibrations.

E. J. Scott, USA

2159. **Shock and vibration instrumentation,** Symposium Nat. Conf. appl. Mech., ASME, State College, Pa., June 1952, 85 pp. $3.

Publication includes seven papers dealing with the characteristics of shock and vibration instruments and application of instrumentation to broad fields, such as blast effects or ship vibration.

The single degree of freedom system in motion measurement, by R. Rosenbaum. Paper reviews fundamental theory of the damped seismic element having a single degree of freedom; phase distortion encountered in complex periodic motion consisting of components of different frequency is discussed for steady-state motion; response to transient excitation is given; basic difference in design of displacement, velocity, and acceleration measuring instruments.

Secondary effects in seismic system instruments, by Gifford E. White. The dynamic response of seismic instruments will not always follow a second-order linear differential equation with constant coefficients. Factors responsible for this include the mass effect from "oil pumping" or oil displaced by the moving mass, shear elasticity of oil, turbulent behavior of low-viscosity oil, varying ambient temperature, varying modulus of elasticity of spring element, and effect of lateral response.

Vibration pickup calibrators, by Robert C. Lewis. Discusses motion generators used for calibrating vibration pickups under steady-state conditions. Included are constant displacement mechanisms such as cam and follower systems, constant force systems employing electrodynamic conversion of current into force, and resonant systems. Calibrations are classified according to whether quantity measured is displacement, velocity, or acceleration. Some existing types of pickup calibrators are described.

Significance of mechanical shock measurements by peak-reading instruments, by Irwin Vigness. Consideration is given to general types of peak-reading instruments used for measurements of mechanical shock. These are: (a) The contact break held against a seating until inertial forces are sufficient to break contact; (b) the reed gage; (c) the crusher gage; (d) the indenter gage; and (e) the fracture gage. Curves are given showing the response of these instruments to simple types of shock motion.

Instruments for measuring and recording shock-wave pressures and responses of structural members, by Harlan E. Lenander. Describes the instrumentation used for the measuring of the forcing function and the response of structures to these forcing functions in the 1951 Operation Greenhouse at the Pacific Proving Ground, Eniwetok, Marshall Islands. Almost 900 measurements were made of pressure, displacement, acceleration, strain, earth pressure, footing pressure, and panel time of break during a nuclear blast.

Shock and vibration instrumentation for ships, by R. T. McGoldrick. Basic requirements of shock and vibration instruments now in use on ships and which author describes include a common reed-type frequency meter, several displacement meters, accelerometers, indicating-shock instruments, and torsional vibration instruments. Current developments in shock and vibration instruments for naval use are discussed.

Some comments on the dynamic testing of aircraft in flight, by Lee S. Wasserman. Paper describes some of the problems in the dynamic testing of aircraft. Criteria for satisfactory dynamic test equipment in aircraft are discussed. Because of a difference in operation as well as a difference in environment, flight-testing equipment requires more careful planning than does similar laboratory equipment. Author emphasizes the need for equipment which is linear and which has a flat frequency response.

P. G. Jones, USA

2160. **Söchting, F., On the computation of eigenfrequencies** (in German), *Öst. Akad. Wiss. math.-nat. Kl. Anz.* **1951,** 132–135, 1951.

The present note contains several remarks concerning the computation of the eigenfrequencies ω^2, which satisfy the differential equation

$$\omega^2 v = F\left(x, y, \frac{\partial^2 v}{\partial x^2}, \frac{\partial^2 v}{\partial y^2}, \ldots\right)$$

where v is the displacement. The author concludes that, if an approximation v_1 differs little in absolute value from the actual displacement v, the corresponding approximation to ω^2 computed from v_1 by an energy principle will also differ little from ω^2. These considerations are related to an earlier paper by the author [AMR **4,** Rev. 565].

Courtesy of Mathematical Reviews J. B. Diaz, USA

2161. **Kupradze, V. D., Solution of a fundamental boundary problem in the displacements for vibrations of an elastic medium** (in Russian), *Soobshchen. Akad. Nauk Gruzin. SSR* **9,** 99–106, 1948.

The boundary-value problem consists in the determination of the displacement vector $\bar{u}(u_1, u_2, u_3)$ which takes prescribed boundary values $f(f_1, f_2, f_3)$ on the boundary S of an open set B in (x_1, x_2, x_3)-space, satisfies the system of equations

$$\Delta\bar{u} + \frac{\lambda + \mu}{\mu} \operatorname{grad} \operatorname{div} u + k^2\bar{u} = 0 \qquad [*]$$

in B, and the radiation condition at infinity if B is unbounded. The uniqueness theorem in the plane case has been discussed earlier [Kupradze, *C. R. Dokladi Acad. Sci. URSS (N.S.)* **6,** (1935, II), 100–104, 1935; and in the space case in a Tiflis dissertation by A. S. Bakalyaev]. In the present paper the author is concerned with the existence of a solution. A "fundamental vibration tensor solution" of [*] is introduced, and "double-layer potentials" with respect to this tensor are then constructed. Using the jump conditions on the boundary for such double-layer potentials, the solution of the (Dirichlet-type) boundary-value problem is sought in the form of a double-layer potential, and an equivalent Fredholm integral equation for the unknown density of the double-layer potential is obtained. For the exterior boundary-value problem the solution exists for any values of the vibration parameter.

Courtesy of Mathematical Reviews J. B. Diaz, USA

2162. **Oniashvili, O. D., On vibrations of a sloping cylindrical shell** (in Russian), *Soobshchen. Akad. Nauk Gruzin. SSR* 9, 425–431, 1948.

The shell under consideration has the shape of cylindrical arch; it is cut out from a cylindrical shell with diaphragms at both ends and is supported on hinges all around the edges. The system of two differential equations and the expression for the frequency of free vibrations of a cylindrical shell with an infinite number of degrees of freedom derived from the above equations were given by V. Z. Vlasov [AMR **1,** Rev. 253].

The author of this paper uses Vlasov's equations and finds the principal mode of free vibrations for a shell (a) initially stressed, (b) free of stress, and (c) the modes of vibrations forced by a periodic load distributed continuously on the surface of the shell. The last case is discussed in detail for the following subcases: (i) The force is directed radially and the magnitude is a simple periodic function of time, independent of the location on the surface of the shell; (ii) the external load is a concentrated periodic force directed radially. The vibrations due to external loads are considered separately for the case when the free vibrations are damped out completely, and for the case when the free vibrations are present and the resulting oscillations are not periodic, beating being the most important occurrence. In this latter case, the author obtains the period of the beats.

Courtesy of Mathematical Reviews T. Leser, USA

2163. **Sakadi, Z., Criticism on the equations of flexural vibration of a thin bar,** *Math. Japonicae* **2,** 79–85, 1951.

The usual equation (1) for flexural vibrations of rods, and (2) the more complicated equations taking into account rotary inertia, and (3) this and also shear distortion are considered. The velocity of sinusoidal waves $y = \exp[i(pt + \gamma x)]$ is determined, and (2) and (3) give results differing from (1) by terms of the same order. The complete three-dimensional elastic theory [see Love, "Elasticity," 4th ed., Cambridge, 1927, p. 291] is used for a circular rod by expansion of the resulting Bessel functions in series, and the difference from (1) is of the same order as the additional terms due to (2) and (3), but differing from them. (3) is closer to the correct solution, but since the error is of the same order as the correction from (1), it is considered not to provide a satisfactory higher-order theory.

E. H. Lee, USA

2164. **Aggarwal, R. R., Axially symmetric vibrations of a finite isotropic disk. II,** *J. acoust. Soc. Amer.* **24,** 6, 663–666, Nov. 1952.

The calculations presented in part I [see AMR **6,** Rev. 1175] have been extended to include vibrations, which are antisymmetric with respect to the central plane of the disk. Curves showing the normal components of the displacements at the boundary surfaces are also drawn, to get the vibration patterns according to the theoretical assumptions made.

From author's summary

2165. **Saibel, E., and Lee, W. F. Z., Vibrations of a continuous beam under a constant moving force,** *J. Franklin Inst.* 254, 6, 499–516, Dec. 1952.

Paper deals with vibrations of continuous beams by working in terms of normal modes of the "simple" beam obtained by removing all intermediate supports. Earlier work by first author [*J. aero. Sci.* **11,** 88–90, 1944], in terms of vibrations due to a

single fixed pulsating force is extended by integration and summation to obtain solution to present problem. Solution of two-span beam is obtained in full, and extension to multispan beam indicated. Numerical results for a particular case agree with those obtained in AMR **4**, Rev. 551.

K. H. Griffin, England

2166. **Saravanos, B., The helicopter in free ground vibration,** *Aircr. Engng.* **24,** 286, 356–360, Dec. 1952.

In applying any of the published analyses of "ground resonance" (self-excited mechanical vibration of rotating-wing aircraft), the designer must first know the effective mass and stiffness of the rotor hub. It is believed that this paper fills a gap in our knowledge by providing a means for calculating these quantities in the design stage, in contrast to empirical estimation or experimental determination after the aircraft is built. The calculations require a knowledge of the helicopter's over-all geometry, fuselage mode shapes and frequencies, and landing-gear spring constants.

A. Gessow, USA

2167. **Liepmann, H. W., On the application of statistical concepts to the buffeting problem,** *J. aero. Sci.* **19,** 12, 793–800, 822, Dec. 1952.

In work on turbulence, communications engineering, and other fields of science involving stochastic processes, a large and growing body of knowledge and concepts has been developed. These ideas have not been used extensively in aeronautical engineering, and this paper presents the basic ideas in such a way that they will be readily grasped by many aeronautical engineers and applied across a much broader range of technology than has been true in the past. The analysis starts by considering the response of a damped oscillator to a random forcing function. The author discusses what kind of information can and should be expected from from such an analysis and what statistical properties must be known about the forcing function. The ideas are applied to the motion of a two-dimensional airfoil moving through turbulent air where the statistical properties of isotropic turbulence are used. The analysis is carried to a point where the engineer should be able to obtain a rather clear picture, both of the general capabilities of statistical methods and of their application to the buffeting problem.

F. H. Clauser, USA

2168. **Botsford, J. H., Lane, R. N., and Watson, R. B., A reverberation chamber with polycylindrical walls,** *J. acoust. Soc. Amer.* **24,** 6, 742–744, Nov. 1952.

A reinforced-concrete reverberation chamber has been constructed with diffusing cylinders of random size cast in the ceiling and walls. Energy loss in the empty chamber is low because the rigid, heavily enameled walls have a low absorption coefficient and the attenuation loss in the air is moderate for such a small volume. Materials are tested in the frequency range from 250 cps to 12 kc, using half-octave noise bands.

From authors' summary

2169. **Holter, N. J., and Glasscock, W. R., Vibrations of evaporating liquid drops,** *J. acoust. Soc. Amer.* **24,** 6, 682–686, Nov. 1952.

An unusual type of vibration of flattened spheroidal liquid drops, occurring under certain conditions, is described and illustrated. Appropriate liquids placed on a sufficiently hot horizontal surface float on a film of their own vapor, which vapor insulates the drop so that it evaporates quite slowly. This phenomenon is known as the Leidenfrost effect. It is under these conditions that drops have been found capable of sustaining large-amplitude regular radial vibrations whose driving force is probably related to the radial flow of vapor below the drops. The vibrating drops are approximately polygons which may have any of 2, 3, 4, . . . n sides, seen by the eye as drops 4, 6, 8 . . . $(2n + 2)$ regular lobes around the circumference. Methods of exciting and recording the effect are described.

From authors' summary

2170. **Stenzel, H., The sound field in the vicinity of vibrating rectangular membranes** (in German), *Acustica* **2,** 6, 263–281, 1952.

Field of sound immediately in front of a vibrating rectangular membrane is calculated and given by general formulas. The field of sound at larger distances is given by many diagrams (curves for p = const) for different ratios of the rectangle sides. Radiation impedance is calculated generally and is compared graphically with the corresponding values for a circle membrane. Results of this paper are discussed together with other recently published papers.

O. Ruediger, Germany

2171. **Valensi, J., and Clarion, Claire, Damped vibration of a sphere submerged in a viscous fluid** (in French), *C. R. Acad. Sci. Paris* **235,** 19, 1097–1099, Nov. 1952.

According to experiments, the motion of a sphere oscillating with finite amplitudes in a viscous fluid and led back by a linear elastic force may be described by addition of a term $\{f_2 \cdot |\dot{x}| \cdot \dot{x}\}$ to the original differential equation $f_0\ddot{x} + f_1\dot{x} + f_2x = 0$ for very small amplitudes. The factor f_2 is determined by a semi-empirical method.

Margot Herbeck, Germany

Wave Motion, Impact

(See also Revs. 2220, 2229, 2300, 2305, 2375, 2378)

2172. **Ruchimskiĭ, M. N., On the computation of a beam acted on by a moving force of variable mass** (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **11,** 187–188, 1952.

2173. **Kothari, L. S., Application of Dirac's δ-function to some problems in classical physics,** *Amer. J. Phys.* **21,** 2, 99–101, Feb. 1953.

Author discusses applications and advantages of Dirac's function in theoretical physics and illustrates its use on hand of examples of classical dynamics. Impulsive functions had already been employed by Heaviside. Their first exact formulation is due to Dirac who made extensive use of them in quantum mechanics.

Given a continuous function $d(x, \epsilon)$ of the properties

$$d(x, \epsilon) = 0 \text{ for } |x| > \epsilon \qquad [1]$$

$$-\infty \int^{+\infty} d(x, \epsilon)\, dx = 1 \qquad [2]$$

the Dirac function $\delta(x)$ is defined as the limit

$$\lim_{\epsilon \to 0} d(x, \epsilon) = \delta(x)$$

Author emphasizes and explains the advantages of impulsive functions in the representation of concentrated external forces or discontinuous initial conditions in boundary-value problems. Among the principal mathematical characteristics of $\delta(x)$ analyzed in the paper is the interesting relation $-\infty \int^{+\infty} f(x) \cdot \delta(x - a)\, dx = f(a)$ and the Fourier series representation of $\delta(x)$.

Examples for illustration of the mathematical concepts are carefully selected. Contents of paper could be extended to the role of $\delta(x)$ in the theory of the Laplace transform, and the "double Dirac functions" of the type $\delta(x) \cdot \delta(t)$ as are used for the representation of space- and time-concentrated forces in advanced dynamics.

M. A. Dengler, USA

2174. Ghosh, M., and Ghosh, S. K., Dynamics of the elastic vibration in a bar excited by longitudinal impact. Part II. Study of the time of collision, *Indian J. Phys.* **26,** 9, 463–471, Sept. 1952.

In a continuation of a previous paper by the authors [AMR **5,** Rev. 354] on the impact of an elastic body on elastic fixed-free and free-free bars of length l, the discussion deals with the general case where the value of Young's modulus E_2 of the impinging body is neither zero nor infinite, and the commonly treated case, where this body is rigid, is obtained by putting $E_2 = \infty$. The equations derived in the previous paper for the duration ϕ of the impact are discussed in some detail, and numerical results are given for a particular case. For a fixed-free bar, curves are given showing the variation of (a) the pressure at impact and time, (b) ϕ and E_2, (c) ϕ and l; for a free-free bar, the relation between ϕ and E_2 is shown. The (pressure, time) curves show the features described in AMR **5,** Rev. 354. As E_2 decreases from ∞, the (ϕ, E_2) curves show a gradual discontinuous increase in ϕ, followed by a sharp drop to a minimum and a subsequent rise. The (ϕ, l) curve relates to $E_2 = \infty$, and it shows that ϕ increases discontinuously with l. R. M. Davies, Wales

2175. Ursell, F., Discrete and continuous spectra in the theory of gravity waves, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 1–5, Nov. 1952. $1.75.

The wave motion of the fluid is discussed for the following cases of canal geometry: (1) Finite length, constant depth and width; (2) infinite length, constant depth and width; (3) infinite length, variable depth, and constant width. It is shown that in case (1) a discrete enumerable set of natural frequencies exists. In case (2), however, the spectrum of frequencies becomes continuous. For modes which are uniform in the direction of the canal width (two-dimensional modes), the spectrum begins at $\nu = 0$; for modes which have a wave length $2\pi/k$ in this direction, the spectrum has as lower limits $\nu = (gk)^{1/2}$, where g denotes the acceleration of gravity.

Most interesting is case (3), which leads to a mixed (partly discrete and partly continuous) spectrum. For $\nu > (gk)^{1/2}$, the spectrum is again continuous, but there exists a number of discrete natural frequencies below this value (edge waves of Stokes). The energy of the modes corresponding to these latter frequencies is not radiated to infinity. Another example of a mixed spectrum is that of a submerged circular cylinder fixed right across the canal of case (2). It is not known whether mixed spectra are also possible for two-dimensional motions. A. I. van de Vooren, Holland

2176. Mapleton, R. A., Elastic wave propagation in solid media, *J. appl. Phys.* **23,** 12, 1346–1354, Dec. 1952.

Author considers two-dimensional solutions of equation of harmonic wave propagation in elastic plates of uniform thickness, with a view to multiple reflection delay lines. Paper involves lengthy mathematical calculations; the main results follow: Modes of vibration are considered that approximate most closely to plane shear waves with displacement normal to faces of plate. The modifications produced if the medium is a single crystal are small if displacement is contained in the plane parallel to the stress-free surface. Plane shear waves in a single crystal propagate with a velocity independent of direction, provided that displacement is parallel to a crystallographic axis. Author applies his analysis to plates of fused quartz and calcium fluoride, comparing performance at 15 mcs. J. M. Jackson, Scotland

2177. Lee, E. H., A boundary value problem in the theory of plastic wave propagation, *Quart. appl. Math.* **10,** 34, 335–346, Jan. 1953.

Problem is the normal impact of cylinder against a rigid target at rest. Nominal stress-strain curve of material of cylinder is assumed concave downward. High impact stresses for which the curve is concave upward and shock waves result are discussed in author's British Official Report no. 57, 1943, from which present solution is taken. Lateral motion is neglected. Complexity results from different differential equations having to be satisfied at a point whether the point is in a state of loading or unloading. Basic theory by von Kármán, Bohnenblust, and Hyers in Lagrangian coordinates is used. After impact, plastic wave is reflected from the free end as an (elastic) unloading wave; in problem discussed, the later just reaches the impact end—it is not previously absorbed by the advancing plastic wave. However, at a certain point, after the unloading wave has passed it, the stress (as determined by the unloading equations) may reach the previous maximum stress there. In this case, discussed here, plastic flow will occur again and the plastic-wave equation must be solved. The determination of the plastic-unloading boundary by forward integration along the characteristics of either differential equation requires ingenuity and great numerical accuracy.

The permanent plastic-strain distribution is determined and the influence on it of the second plastic region found to be small. The major part of the strain occurs at impact end.

Paper is important both for the results achieved and for illustrating the essential difficulties arising in boundary-value problems of the theory of plasticity.

W. Freiberger, England

2178. Selberg, H. L., Transient compression waves from spherical and cylindrical cavities, *Ark. Fysik* **5,** 1/2, 97–108, 1952.

Paper is a preliminary attempt to describe the phenomena near a borehole after the detonation of a charge (during rock blasting). In first part, author calculates the stress in an infinite elastic solid when a uniform normal pressure acts over the surface of a spherical cavity for a short time. The analysis depends on the fact that $r^{-1}\phi\{t - (r - r_0)/c\}$, with ϕ arbitrary, is a solution of the wave equation. Since the solid is assumed to be infinite, the effect of reflected waves is not considered. The solution is illustrated by numerical results for a solid with Poisson ratio 1/4. In second part, the infinite solid is assumed to have a cylindrical cavity (of infinite length); in this case, the solution is derived using the Laplace transform and the properties of Bessel functions.

I. N. Sneddon, England

2179. Pierson, W. J., Jr., On the propagation of waves from a model fetch at sea, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 175–186, Nov. 1952. $1.75.

Models of surface waves propagated in one dimension from a source of limited duration are given. Fourier's integral theorem is applied, and solutions obtained for infinitely deep water give the waves arriving at a distance from the source.

Results from an assemblage of Gaussian wave packets are used in considering the transformation of sea into swell. Basis of comparison is the dispersion of the model disturbance into a well-resolved spectrum. Energy in the longer period part of the spectrum travels at greater group velocity, and this feature of model explains the decrease with time which observed periods of swell arriving from a distant storm exhibit. The energy maximum remains associated with the same period in the spectrum of the model, and there is no shift in spectrum. Reviewer believes that the observed period increase of swell with increasing distance from storm is, therefore, not explained. Introduction of selective attenuation seems necessary [Ewing and Press, *Ann. N. Y. Acad. Sci.* **51,** 3, 453–462, May 13, 1949], although author concludes otherwise. Author outlines method for representing irregular groups of storm waves.

Properties of propagation in a dispersive medium are instructively illustrated by the models. Relationship of these properties to sea and swell has been emphasized previously, especially by Barber and Ursell [*Phil. Trans. roy. Soc.* (*A*) **240**, 824, 527–560, Feb. 24, 1948] and Sverdrup [*Trans. Amer. geophys. Un.* **28**, 3, 407–417, June 1947]. R. S. Arthur, USA

2180. **Munk, W. H., and Arthur, R. S., Wave intensity along a refracted ray,** "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 95–108, 1952. $1.75.

With considerable ingenuity, authors have developed the equation of wave intensity in a continuous-velocity field. Using this equation, a method is established for the direct determination of the wave intensity along a ray when only the ray path and ray velocity are known. The procedure is illustrated by applications to special types of underwater topography. Methods are demonstrated for obtaining solutions in the following cases: shelf of uniform depth; straight, parallel contours; ridge and trough; complex bottom. W. Ornstein, USA

2181. **Pohle, F. V., Motion of water due to breaking of a dam, and related problems,** "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 47–53, 1952. $1.75.

The Lagrangian representation of the two-dimensional hydrodynamical equations of motion is used to investigate the motion of an ideal fluid during the early stages of the breaking of a dam. It is shown that the results agree with those obtained by different methods by C. K. Thornhill and H. M. Westergaard.

G. N. Cox, USA

2182. **Davies, T. V., Symmetrical, finite amplitude gravity waves,** "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 55–60, 1952. $1.75.

Author gives a short account of some important results on symmetrical finite-amplitude gravity waves, including the solitary wave. See Davies [AMR. **5**, Rev. 355] and Packham [AMR, **5**, Rev. 3326]. G. Supino, Italy

Elasticity Theory

(See also Revs. 2176, 2243, 2247, 2249)

2183. **Schäfer, A., The friction in the compression of rolls having different moduli of elasticity** (in German), *Arch. Eisenhüttenw.* **23**, 7/8, 253–256, July/Aug. 1952.

A mathematical analysis is given of the stresses developed at the interface of two rolls or of a roll and a flat body having different moduli of elasticity, and considering the presence of frictional shear stresses at the interface. This contact area, then, consists of three regions, a region of sticking in the center bordered by regions of slipping. The calculation of the stresses also yields the directions of the principal stresses, and agreement between theory and photoelastic experiment is obtained.

G. Sachs, USA

2184. **Polozhiĭ, G. N., The solution of some problems of the plane theory of elasticity for regions with angular points** (in Russian), *Ukrain. mat. Zh.* **1**, 4, 16–41, 1949.

Using the author's terminology, in the third boundary-value problem of the plane theory of elasticity the normal displacement and the tangential stress are prescribed on the boundary, while in the fourth boundary-value problem the tangential displacement and the normal stress are prescribed on the boundary. The third boundary-value problem, when the tangential stress is zero, was considered by Mushkelishvili ["Certain fundamental problems in the theory of elasticity," Leningrad, 1933, p. 216; Moscow, 1935, pp. 303–318; *Dokladi Akad. Nauk SSSR* (*N.S.*) **3**, 7–11, 1934] and solved by him for domains which are mapped on a circle by means of rational functions. For domains with smooth boundaries, this problem was solved by D. I. Sherman [*Prikl. Mat. Mekh.* **7**, 413–420, 1943], but it has not yet been discussed in general for domains with boundaries having angular points. In the present paper, the author solves the third and fourth boundary-value problems for a rectangle, acute-angled triangle, and right triangle, under certain hypotheses concerning the growth of the stresses near the angular points.

Courtesy of Mathematical Reviews J. B. Diaz, USA

2185. **Polozhiĭ, G. N., Application of boundary problems of the theory of functions to the solution of the third problem of the plane theory of elasticity for an infinite plane with triangular and regular polygonal openings** (in Russian), *Ukrain. mat. Zh.* **2**, 3, 115–124, 1950.

The third boundary-value problem of the plane theory of elasticity consists in the determination of stresses and displacements in the interior of a plane domain when the normal component of the displacement and the tangential stress are prescribed on the boundary of the domain. The solution of this problem, for certain domains bounded by piecewise-rectilinear curves, was given earlier by the author [AMR **3**, Revs. 845, 1243]. The present paper contains the solution of the third boundary-value problem for the domains mentioned in the title.

Courtesy of Mathematical Reviews J. B. Diaz, USA

2186. **Williams, M. L., Stress singularities resulting from various boundary conditions in angular corners of plates in extension,** *J. appl. Mech.* **19**, 4, 526–528, Dec. 1952.

The author treated the bending problem of plates with angular corners in an earlier paper [Proc. First U. S. natl. Congr. appl. Mech., June 1951, J. W. Edwards, Ann Arbor, Mich., 1952]. Now he explains the stress singularities for the plate in extension. By means of the eigenfunctions he shows thatl, for vertex angles between 180° and 360°, all considered cases of boundary conditions have stress singularities. Between 63° and 180°, only mixed boundary conditions may give a singularity.

H. Neuber, Germany

Experimental Stress Analysis

(See also Revs. 2159, 2221, 2252)

✎2187. **Fink, K., edited by, Principles and applications of the strain gage [Grundlagen und Anwendungen des Dehnungsmesstreifens],** Düsseldorf, Verlag Stahleisen, 1952, 219 pp. DM 20.

This book is a compilation of a series of papers given in Düsseldorf, Germany, in July 1951, at a meeting held for the expressed purpose of familiarizing German engineers with the properties and applications of resistance strain gages. The result is a neat, compact reference source, and Americans must wonder why, despite their long lead in this field, there exists no equivalent publication in English. A total of 19 papers has been printed. The initial sections by Fink and Rohrbach deal with fundamentals and measurement techniques, but also report tests on linearity, hysteresis, temperature, and creep behavior of both paper-backed (Phillips) and plastic gages (Huggenberger). Boiten gives a remarkably complete treatment of the problem of applying strain gages to work within close limits on steel structures outdoors. Emschermann shows that strain gages operating in electric fields can be shielded by simply wrapping them in thin metal foil.

Svenson demonstrates a novel device for measuring side force on an automobile wheel, and also shows how bending in a cantilever can be measured, even when the outside is inaccessible, by inserting preformed Huggenberger gages into $1^1/_{16}$-in. diam holes drilled into the end. Other papers deal with the applications of strain gages to stresses in railroad ties, mine supports, funicular railways, fatigue testing, and gas turbines. Vancrombrugge and Bühler discuss residual stress measurements, and Lueg and Fink close by describing dynamometers for use in research on plastic forming. The usefulness of most of the papers is increased by the excellent bibliographies they include. E. G. Loewen, USA

2188. Jones, E., and Maslen, K. R., The physical characteristics of wire resistance strain gauges, *Aero. Res. Counc. Lond. Rep. Mem.* 2661, 44 pp., Nov. 1948, published 1952.

The introduction of this report refers to the advantages of wire-resistance strain gages in comparison to other strain gages. The upper frequency limit is about 40,000 cps; changes of strain of 10^{-6} can be detected; temperature changes can be completely compensated; the gages can be attached to a curved surface quite easily; strains over very small gage length—about $^1/_{16}$ in.—can be recorded; the relation between electrical output and strain is linear for all types of gages up to strains of about 0.5%, for some types up to strains of about 5%; signals from several gages can be added or subtracted electrically to measure directly average stresses, bending moments, and shears. Finally, the gage is cheap in initial cost, is easily applied, and can therefore be used in large numbers.

The construction of usual types of wire-resistance strain gages (flat-grit type and the flattened spiral type) and the material in common use for wires and for cements (cold-setting of Durofix type and thermosetting of the Bakelite type) are described. The mechanism whereby strain effects change of resistance is discussed.

The effect of tensile strain on the electrical resistance of fine metallic wires [silver, platinum, copper, iron, nickel, Ferry (60/40 cupro-nickel), Minalpha (manganin), 10% iridium-platinum, 10% rhodium-platinum, 40% silver-palladium] are tested. For most purposes, wire of Ferry is the best one. The strain sensitivity for annealed Ferry is nearly 2 and constant up to the high strain of about 7%. An equipment for calibration of strain gages is described (beam bent by four point loading).

The influence of transverse strain on strain measurements is computed for flat-grid type of gage. The transverse effect on the gage factor of flattened spiral type can be neglected. Possible causes of error, including the effects of imperfect sticking, change of resistance by incomplete drying, by humidity, by change of isolation resistance, and by temperature are discussed. Methods of drying and waterproofing (coats of Di Jell wax, of hot wax, and of shellac Japan, covering by silica gel crystals) are dealt with.

The effect of the passage current on strain measurements (zero drift during warm-up and after temperature stabilization) and drifts under load ($\Sigma = \pm 2 \times 10^{-3}$) at various temperatures (19–95 C) is required. Current-carrying capacity is given for different wires, diameters of wire, and spacings of wire. Optimal resistance values for strain gages are calculated.

The behavior of strain gages at high tensile strains, under repeated loadings, in compression, at low (−50° C) and high (+300 C) temperatures is reported. K. Fink, Germany

2189. Miller, J. A., Improved photogrid technique for determination of strain over short gage lengths, *Proc. Soc. exp. Stress Anal.* **10,** 1, 29–34, 1952.

Methods are described for photographing on a metal a grid of well-defined lines 0.0006 in. wide, spaced 0.01 in. apart. To obtain this precision, a master grid was ruled for the purpose. Excellent definition of lines has been obtained by using cold top enamel and Dyrite black contact emulsion. Applications of the method to the study of strain concentrations in the plastic range are described. A replica technique for use in measuring strain on curved surfaces is described. From author's summary

2190. Gentric, A., Contribution to the experimental analysis of the elastic behavior of tanks under internal pressure (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 99–110, 1952.

Stresses near the shoulders of a cylindrical pressure vessel with curved ends were found by use of resistance strain gages. Since material would be overstressed under working conditions, the effectiveness of various kinds of reinforcement was determined.
M. P. White, USA

2191. Bühler, H., and Schreiber, W., Complete determination of the internal stress state in metallic hollow cylinders (in German), *ZVDI* **94,** 35, 1147–1151, Dec. 1952.

Abbreviated version of paper reviewed in AMR **6,** Rev. 1840.
R. Week, England

2192. Dätwyler, G., New applications of the hot-wire anemometer (in French), *C. R. Acad. Sci. Paris* **235,** 19, 1101–1103, Nov. 1952.

A short theoretical note is presented on the behavior of a constant-current hot wire placed perpendicularly to an air flow in which small fluctuations $(\overline{u^2})^{1/2}$ and $(\overline{t^2})^{1/2}$ are imposed on the mean velocity and ambient-air temperature U and t_a.

With the wire sensitivity for these fluctuations, if $t_{wire} - t_a < 400°$, evaluated from Ulsamer's heat-loss equation $Nu = c \cdot Re^n$, author shows that the voltage fluctuations across the wire may only be interpreted as resulting exclusively from the turbulence-velocity fluctuations if $2(\overline{ut})/(\overline{t^2})^{1/2} = U/n(t_w - t_a)$. It is also shown that deducing the mean ambient temperature from the minimum indication of a hot-wire thermometer is only permitted in case the correlation $\overline{ut}/(\overline{u^2})^{1/2}(\overline{t^2})^{1/2} = 0$ or if $\overline{t^2} = 0$.

In reviewer's opinion, the last case is already fully covered by the condition that the correlation be zero, as $\overline{t^2} = 0$ can only be interpreted as constant ambient-air temperature, in which case automatically no correlation exists.

Introducing a time mean value t_a if the air temperature varies with time, means that $\overline{t} = 0$ and therefore $\overline{t^2}$ has a finite value.
Yap Kie Jan, Holland

2193. Cunningham, C. B., Telemetering, recording, and analyzing shock and vibration data, *Proc. Soc. exp. Stress Anal.* **10,** 1, 125–134, 1952.

A description is given of a method of telemetering, recording, and analyzing information concerning the behavior of mechanical systems such as rockets, planes, and ships. The telemetering system does not limit the frequency range of the over-all recording system, which is presently between 2 and 5000 cps. The principal advantage of the method is its ability to reproduce, at the convenience of the operator, the electrical signals originally provided by the pickup units. This allows these signals to be analyzed quickly and easily by electrical methods.
From author's summary

2194. Lisowski, A., Optical method of measurement of elastic deformations of three-dimensional systems on models (in Polish), *Inżyn. Budown.* **9,** 3, 90–94, Mar. 1952.

Paper presents contribution to large-scale thin-wall structures such as hangars, etc. In the first part, author derives all the required equations for resultant normal and shearing forces and

bending moments in terms of deformations in a thin-wall structure (shell). These equations, as expected, are analogous to known equations for plates. Experimental optical method refers to celluloidal models (1–50) on which a net of lines is traced. The translations of knot points of net in three perpendicular directions are measured by means of microscope. This allows the deformations, and next, stresses, forces, and bending moments to be calculated by means of equations previously derived. Explanation of diagram of vertical translation on a model of a hangar closes the paper. M. Z. Krzywoblocki, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Rev. 2212)

2195. **Eisenberg, P., and Whicker, L. F., Large elastic bending of heavy, uniform cantilevers with hydrodynamic loading,** *David W. Taylor Mod. Basin Rep.* 839, 26 pp., Nov. 1952.

In this report, computations are extended to the case of elastic members, and results are derived for the shape, bending moments, and shear of a uniform cantilever. The beam is assumed to be symmetrical about, and to bend only in the plane of motion.

The loading is made up of the weight of the bar and the hydrodynamic force. The latter is assumed to follow the "sine-squared law," i.e., unit loading is $R \cdot \sin^2 \phi$, where R is the drag per unit length of beam when normal to the direction of motion, and ϕ is the angle between the tangent to the bar and the direction of motion. Assuming the applicability of the Bernoulli-Euler law, assuming linear Hooke's law and no change in total length of beam, neglecting warping of the sections, and neglecting the tangential forces, the slope of the beam as a function of the distance along the beam is derived in the form of a nonlinear integrodifferential equation. An approximate solution is obtained by expansion in a Maclaurin series in which the coefficients of the first 10 terms are evaluated.

Values of total shear as compared with experimental results are shown to be in good agreement for those cases in which available drag coefficients apply. From authors' summary

2196. **Levy, S., Influence coefficients of tapered cantilever beams computed on SEAC,** *J. appl. Mech.* **20,** 1, 131–133, Mar. 1953.

Author describes rapid and accurate computing method for nonuniform cantilever beams in bending, using a basic code devised for the National Bureau of Standards electronic automatic computer SEAC. The code may be applied without modification to beams with any number of stations between 1 and 23 at which it is desired to compute deflections when a unit force is applied at any one of the stations. The computational procedure carried out by SEAC, which is based on ordinary beam theory, uses the assumption that $1/EI$ varies linearly between stations. Influence coefficients at nine points on a tapered beam, which took about two days to compute and check with a conventional computing machine, were computed in three minutes by SEAC.

Reviewer's experience with the method indicates that its use leads to a considerable saving in computation time.

S. Goodman, USA

2197. **Stepanov, R. D., and Sherman, D. I., Torsion of a circular bar weakened by two longitudinal cylindrical circular cavities** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **11,** 127–150, 1952.

The Saint Venant torsion problem for circular cylinders weakened by longitudinal circular cylindrical cavities was previously considered by G. M. Goluzin [*Mat. Sbornik* **41,** 246–276, 1934] and Chih-Bing Ling [AMR **1,** Rev. 40]. The method of solution proposed by Goluzin is based on an algorithm of successive approximations, the effectiveness of which has not been tested on special problems. Ling reduces the problem to the solution of an infinite system of linear equations and obtains an approximate solution by truncating the system. Numerical examples considered by Ling suggest that his method may not lead to satisfactory results when the radius of one of the cavities exceeds the shortest distance from the exterior boundary to the boundary of the cavity. The authors of this paper solve the problem stated in the title by constructing an auxiliary density function defined on the boundary of the triply connected domain under consideration. The complex torsion functions are then determined from the density function by integration. The density function is shown to satisfy a certain integral equation, which is solved approximately by reducing it to a system of algebraic equations. The authors do not give a rigorous justification of the approximations, but rather crucial examples selected by them suggest that their method is effective when other methods are expected to fail. The essential ideas of this paper are based on considerations previously employed by Sherman [AMR **2,** Rev. 1111; **5,** Rev. 1023] in solving similar problems for doubly connected domains.

I. S. Sokolnikoff, USA

2198. **Pugsley, A. G., The gravity stiffness of a suspension-bridge cable,** *Quart. J. Mech. appl. Math.* **5,** part 4, 385–394, Dec. 1952.

Paper is mainly concerned with the cable condition determining the horizontal component of the cable tension due to live load in design of suspension bridges. If q is the vertical dead-loading per unit length of the bridge and v is the vertical deflection due to live-loading, author points out that the cable condition in the conventional form expressed by the equation $\int_0^L vq\, dx = 0$, is erroneous, especially in the case of an isolated cable with a concentrated load. The nonlinear response of the cable to vertical loads and the resolution of the afore-mentioned difficulty are treated in more detail.

It seems to reviewer that the author conceived the idea for this paper from Kármán and Biot, "Mathematical methods in engineering" (McGraw-Hill, 1940) where a brief introduction to the theory of suspension bridges is given. On the other hand, the author seems unaware that the problem is treated in much detail by several authors [A. A. Jakkula, "Theory of suspension bridges," *Publications IABSE* **4,** 1936; G. C. Priester, "Application of trigonometric series to cable stress analysis of suspension bridges," *Engng. Res. Bull.* no. 12, Univ. of Mich., 1929; A. Selberg, "Design of suspension bridges," *K. norske Vidensk. Selsk. Skr.* no. 1, 1945] and that they all conclude this effect may generally be neglected. In special cases where it should be taken into account, methods for calculation of this correction term are given. Reviewer feels that the author has perhaps overestimated the influence of this effect. L. N. Persen, Norway

Plates, Disks, Shells, Membranes

(See also Rev. 2186)

2199. **Burrows, W. R., Michel, R., and Rankin, A. W., A wall thickness formula for high-pressure high-temperature piping,** ASME Ann. Meet., New York, Dec. 1952, Paper 52-A-151, 9 pp., 11 tables.

After a study of 31 formulas for pipe-wall stresses, the authors, acting as a subcommittee of the ASA B31 Sectional Committee, Code for Pressure Piping, recommend the following formula: $t = p^D/2S + 2yp$, where t is minimum thickness, p internal pressure, D outside diameter, S allowable stress value, y temperature-dependent parameter with the following values:

Temp, F	900 and below	950	1000	1050	1100	1150 and above
y, ferritic steels	0.4	0.5	0.7	0.7	0.7	0.7
y, austenitic steels	0.4	0.4	0.4	0.4	0.5	0.7

Marshall Holt, USA

2200. Gray, C. A. M., The analysis of fully restrained slabs under concentrated loads, *J. appl. Mech.* **19,** 4, 422–424, Dec. 1952.

Mushkelishvili's solution of the biharmonic equation is used to develop a method of finding approximate values for the bending moments in a thin flat elastic slab clamped round its edge and acted on by one or more point loads normal to its plane. To illustrate the method, the values for the bending moment at various points are worked out for the case of (a) a square slab, and (b) an infinitely long rectangular slab, each loaded at its center. Where comparison with known results is possible, the agreement is good. D. M. A. Leggett, England

2201. Yusuff, S., Large deflection theory for orthotropic rectangular plates subjected to edge compression, *J. appl. Mech.* **19,** 4, 446–450, Dec. 1952.

A theory is presented of the large deflections of orthotropic (orthogonally anisotropic) rectangular plates when the plate is initially slightly curved and its boundaries are subjected to the conditions prevailing in edgewise compression tests. Results are given of computations carried out for four different combinations of load and lamination in Fiberglas panels. These theoretical results duplicate the substantial variations in the load-strain and load-deflection diagrams obtained earlier in experiments at the Polytechnic Institute of Brooklyn.

From author's summary by V. Kopřiva, Czechoslovakia

2202. Lew, H. G., Bending of thin plates with compound curvature, *NACA TN* 2782, 49 pp., Oct. 1952.

A doubly curved thin plate is taken as a part of a shell of revolution bounded by two meridians and two parallels. The thin-shell theory is used to discuss its small deformations under various types of edge conditions. The problem is reduced to two differential equations of the fourth order with constant coefficients. The case of the meridian curve given by $r = a + \mu a(1 - z^2/l^2)^2$ is discussed in detail and numerical results have been obtained. It is found that the deflections are largest at the part of the plate with negative Gaussian curvature.

B. R. Seth, India

Buckling Problems

2203. Yoshimura, Y., and Uemura, M., The buckling of spherical shells due to external pressure (in Japanese), *Rep. Inst. Sci. Tech., Univ. Tokyo* **3,** 11, 12; 316–322, Nov., Dec. 1949.

Among many attempts which have been made to explain the discrepancy between the experimental buckling value of a spherical shell and theory, the concept of "Durchschlag" suggested by Biezeno, von Kármán, and H. Tsien is considered to be the most reasonable one. But as the assumption used in von Kármán's calculation with regard to the deformation of the shell is not natural, the same problem is solved once more as exactly as possible, by dealing with the equilibrium equations with finite displacement and assuming the reasonable functional form of the deformation.

The considerable differences in the results obtained in the present paper from that of von Kármán and Tsien are that the postbuckling stable equilibrium positions exist also in the region of internal pressure beyond certain values of deformation and solid angle of the buckled part, and that the minimum of the envelope of the postbuckling equilibrium curves does not exist. Using these results, an opinion as to the mechanism of buckling is proposed. From authors' summary

2204. Gercke, M. J., Generalization of Euler's buckling formula (In German), *Bauingenieur* **27,** 12, 433–436, Dec. 1952.

Author seeks a general solution for buckling of straight bars of constant section which permits consideration of any type of end-support constraint, i.e., elastically restrained in displacement and rotation. The classic Euler cases (free, hinged, or clamped ends) form limiting cases of the analysis. The general solution is studied by means of a method of H. Jung [AMR **5.** Rev. 4120] employing Fourier's transformation to obtain the critical load. The author introduces the "Einspannungsgrad" $\bar{v}$, the "Abstuetzungsgrad" $\bar{c}$, and a magnitude $\bar{P} = P \cdot l^2/E \cdot I$ (called "Bezogene Knicklast") and arrives at a general equation for $\bar{P}$, which solves the stated problem. A. M. Guzmán, Argentina

Structures

(See also Revs. 2198, 2263–2277)

2205. Donato, L. F., Lectures on construction. Part II. Metallic structures [Lezioni di costruzioni. Parte seconda; costruzioni metalliche] (in Italian), Pisa, Colombo Cursi, 1948, vii + 324 pp. Lire 3000.

This volume belongs to a series of four, two of which were reviewed previously [AMR **6,** Revs. 379, 380]. It deals with metallic structures and includes considerations on several types of joints and loading conditions. The book has been written for engineering students. A. J. Durelli, USA

2206. Donato, L. F., Lectures on construction. Part III. Reinforced concrete. Vol. 1 [Lezioni di costruzioni; Parte terza: Cemento armato; volume primo] (in Italian), Pisa, Colombo Cursi, 1952, x + 483 pp. Lire 5000.

This is the last of the published volumes in the series mentioned in the previous review. It deals with reinforced concrete and has two parts; one deals with properties of concrete and reinforced concrete, and the other deals with the design of simple components loaded under tension, compression, and torsion. Several problems have been included for the benefit of students.

A. J. Durelli, USA

2207. Hamilton, S. B., The historical development of structural theory, *Proc. Instn. civ. Engrs.*, part III, **1,** 3, 374–402, Dec. 1952.

2208. Van Beek, E. J., Practical analysis of statically indeterminate aircraft structures (in Dutch), *Ingenieur* **64,** 52, L.47–L.54, Dec. 1952.

A general discussion is given of the practical application of the methods described by Ebner and Köller [*Luftfahrt-Forsch.* 14, p. 607, 1937] and Michielsen [AMR **3,** Rev. 256].

M. Botman, Holland

2209. Steinbacher, F. R., and Gerard, G., Aircraft structural mechanics, New York, Toronto, London: Pitman Publ. Corp., 1952, xvii + 346 pp. $6.50.

This book, the sixth in the Pitman Aeronautical Series, has been written for undergraduate aeronautical instruction beyond the

elementary courses in strength of materials. The first four chapters contain a brief treatment of indeterminate structures and a summary of the mechanics of straight and curved beam bending, including the various interpretations of the slope, moment, and shear diagrams. Then, inasmuch as the primary extensions of applied mechanics which are peculiar to aeronautical structures are, first, the concept of shear flow and, second, the use of thin sheet material in the buckled state as a load-carrying member, the authors devote four chapters to shear phenomena. The third main section deals with the subject of instability and covers columns and flat plates under separate and combined loadings, thin-walled compression elements, and sheet-stringer combinations. The appendix contains a convenient summary of section properties.

There does not appear to be much new information in the book, but rather it contains a well-organized and selective presentation of pertinent information containing relatively late (1949) research results. References are few but adequate for student use. In the reviewer's opinion, some additions which might have enhanced the value of the volume on the student level are (1) an explanation of the shear lag phenomenon; (2) a discussion of minimum energy methods for solving indeterminate structures in those cases when the "exact" solutions described are impractical; (3) a brief description of digital and analog calculation equipment as it affects the nature and accuracy of the solution of the idealized representation of the actual structure; and (4) a treatment of aircraft loads, load analysis, and load factors. Of these four items, the last is probably the most important; lying as it does between aerodynamics and structures, the subject is frequently not treated in texts of either field.

The book is recommended as a concise and lucid exposition amply sprinkled with examples and problems. It is the reviewer's opinion that, in addition to academic use, the book will be useful to the practicing engineer for reference, particularly the latter chapters summarizing the current status of instability problems in the plastic regime. M. L. Williams, Jr., USA

2210. **Schuerch, H. U., Structural analysis of swept, low aspect ratio, multispar aircraft wings,** *Aero. Engng. Rev.* **11,** 11, 34–41, Nov. 1952.

The hypothesis of rib sections free to warp but having infinite bending rigidity (no chord camber) classifies this paper among the classic wing analyses, like the von Kármán-Gabrielli theory and the many extensions of that one. (With respect to those, important progress is made in this paper by abandoning the concept of elastic axis. The twist is referred to an arbitrary axis whose deflection is then determined.) The torsion of the cells between spars considered as separate from the bending of spars also is strong simplification found in old papers. However, the experimental verification makes this work valuable from an engineer's viewpoint.

Formulas defining "effective" bending and torsional inertia give useful relations between the rigidities of the single elements and the over-all rigidities. C. Riparbelli, USA

2211. **Bleich, H. H., Nonlinear distribution of bending stresses due to distortion of the cross section,** *J. appl. Mech.* **20,** 1, 95–104, Mar. 1953.

Paper presents a theory to explain the nonlinear distribution of bending stresses at a ship's cross section consisting of a main hull and of a superstructure whose sides are offset horizontally from those of the hull. Hull and superstructure are considered as separate beams constrained to act together by horizontal shear forces and by vertical forces imposed at junction of hull and superstructure and arising from the elastic resistance of deck framing or bulkheads. Analysis of simple two-cell prismatic structure subjected to uniform bending moment is developed by applying theorem of stationary potential energy on basis that stress distribution is linear in each separate cell. Result indicates that stress distribution can be expressed as a linear combination $\sigma = \sigma_N + \Phi\Delta\sigma$, where σ_N is stress resulting from Navier's hypothesis, Φ is a nondimensional deviation factor, and $\Delta\sigma$ is a corrective stress. Deviation factor is function of geometry and stiffness of deck framing. By letting this factor vary along length of vessel, the conclusion is generalized, without formal development, to apply to a two-cell structure of variable cross section and elasticity of deck framing and subjected to an arbitrary loading. M. St. Denis, USA

2212. **Turazza, G., Calculation of pipes in prestressed reinforced concrete** (in French), *Tech. mod. Constr.* **7,** 12, 364–368, Dec. 1952.

The tube is considered to be composed of three layers, viz., the tube itself, the prestressing wires, and the protecting cover. Paper deals mainly with losses of prestress due to several causes. One cause is that, when the prestressing proceeds from one extremity of the tube to the other, its diameter shortens in *all* its cross sections; i.e., while the prestressing is continued, there is a loss of prestress in the sections already prestressed. The other causes are creep of concrete and steel and shrinkage of concrete. The interaction of the three layers under various conditions is analyzed under simplifying assumptions and a numerical example is given. Author realizes complexity of problem and lack of sufficient data on strength properties of concrete, and emphasizes that no strict coincidence between his theory and the actual behavior can be expected. H. Craemer, Germany-Egypt

2213. **de Leiris, H., and Jacquet, P.-A., Corrosion under tension and bursting of containers for compressed gases** (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 165–178, 1952.

Author discusses the bursting strength of compressed gas vessels as affected by corrosion on both the inner surface, due to the presence of the contained gas, and on the exterior surface due to ocean atmospheric conditions. The complexities of the problem do not allow clear-cut conclusions.

C. O. Dohrenwend, USA

2214. **Legris, J., Strength of materials. Formulas for statically determinate and indeterminate beams. Investigation for the Office of Naval Construction** (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 131–162, 1952.

Paper presents slope-deflection equations for various beams of uniform and nonuniform cross section, and investigates effects of redundancies on such systems. J. Heyman, England

2215. **Haas, A. M., The calculation of reinforced-concrete roof shells. III** (in Dutch), *Ingenieur* **64,** 50, Bt. 74–Bt. 78, Dec. 1952.

In the third part of this expository article, author gives a survey of simplified methods of calculation. Limits of application of the methods should be clearly stated. Much research remains to be done on the problem. W. L. Esmeijer, Holland

2216. **Morgan, V. A., An exact method of analysis of continuing parabolic arches,** *Concr. Constr. Engng.* **47,** 11, 343–352, Nov. 1952.

Using the methods of moment distribution and slope deflection, author gives formulas for the bending moments and thrusts on continuing arches which may be supported on flexible columns.

Reference is given to previous papers by author [title source, **41**, **42**, Apr. 1946, Oct.-Nov.-Dec., 1947].

C. J. Bernhardt, Norway

2217. John, R., Structures. Practical examples [Hochbaukonstruktionen Rechnungsbeispiele aus der Praxis], Wien, Springer-Verlag, 1952, vii + 208 pp., 181 figs., 47 tables. $6.45.

This is entirely a problem book. It begins with the calculation of shearing forces and bending moments for a simple beam and progresses through problems in foundations and design of wood, concrete, and steel structures. Solutions for the 108 problems covered are clearly and simply presented. Appendix contains 50 pages of reprints from DIN Standards and tables of properties of sections. The book is a good review and summary of basic structural calculations. M. W. Jackson, USA

2218. Bölcskei, E., Trusses on V legs (in German), *Acta Techn. Hung., Budapest* **4**, 1/4, 155–168, 1952.

Author advocates a new kind of portal frame wherein the stanchions are replaced by two compressed members forming a V. The theory is developed for a frame with two hinged V supports; a numerical comparison between the moment diagrams in this frame and a conventional one shows a distinct advantage for the new solution (about 40% economy). On the other hand, the new structure is more affected than the conventional one by horizontal movements of the foundations.

Author gives the drawings for two highway bridges, each of about 80-ft span, showing that a somewhat aesthetic aspect may be achieved. One of these bridges has been actually built, and the measurements made during the load tests show good agreement with the calculations. Ch. Massonnet, Belgium

2219. Cassie, W. F., The influence of tyre pressure on the design of aerodrome pavements, *J. roy. aero. Soc.* **56**, 501, 691–700, Sept. 1952.

Author presents a brief critical review of the existing methods of design of flexible and rigid airfield pavements, indicating the weak points of methods based largely on empirical approach, such as the CBR method. He shows how an increase in tire pressure for the same equivalent single wheel load will result in increased shearing stresses, mostly in the upper layers of pavements. It is a timely warning for the modification of design curves based on wheel loads, if the trend toward increase in tire pressures continues. M. V. Smirnoff, USA

2220. Hammond, R., Heavy machine foundations. An unusual arrangement adopted for an 8-ton steam hammer, *Machinery, Lond.* **81**, 1094–1097, 1106, Nov. 1952.

Article describes briefly a heavy concrete foundation which includes an upper and lower inertia block, each prestressed to avoid fatigue, failure, and constructed of Prepakt concrete. Rubber springs, steel springs, and friction dampers separate the various parts. The concrete part of this foundation is described in more detail in the *J. Amer. Concr. Inst.*, 421–444, Jan. 1953.

P. M. Ferguson, USA

2221. Cox, H. L., and Mitchell, S. E., The measurement of very slow movements in large structures, *Proc. Instn. civ. Engrs.* **1**, 6, 682–708, Nov. 1952.

A method is described for the detection and measurement of movements of structures which seem to be distinct from original settlements and continue slowly over a long period of time. Special micrometers are used to indicate the changing relative positions of two steel pegs to which the movement is communicated. The readings are accurate under favorable conditions to 0.0001 or 0.0002 in.

The application of the method for some years at the Tower of London and Rochester Bridge has revealed what appear to be persistent movements of whole structures through a few hundredths of an inch each year. Comparative measurements at one position in the Tower of London suggest, further, that one stratum is moving with respect to another below the surface of the earth.

Previous observations by other workers, who found movements of the same order of magnitude in London and elsewhere, are briefly mentioned. From authors' summary

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2177, 2231, 2347)

2222. Anderson, S. L., Cox, D. R., and Hardy, L. D., Some rheological properties of twistless combed wool slivers, *J. Text. Inst. Trans.* **43**, 8, T362–T379, Aug. 1952.

Authors describe experiments on wool slivers carried out to determine force/displacement properties to break under a variety of conditions. The apparatus used and method of handling the relatively fragile sliver are described. Effects of speed of testing, lateral compression, and oil content on the rupture force are described. A constant rate-of-extension tensometer with photographic load recording was used for the sliver, and a simple chainomatic device for measuring the static withdrawal force of single fibers. The dynamic withdrawal force was measured continuously as a function of displacement of fiber by a torsion wire loadmeter with photographic recording.

For the sliver, as the extension increases the force rises to a maximum and falls to zero when no fibers of the tufts held in the two grips are in contact. Since the extension to maximum force did not vary a great deal with conditions of test, only the maximum force, called the rupture force, was studied. It was found to increase 1.7 times with velocity of testing over the range 10–350 cm/min. Compressing the sliver, reducing its porosity (measured as air space in cross section), caused the rupture force to increase. This force also increases with oil content above 5% oil, but no effect was seen in the normal working range (2.5–5%). The effect of storage was investigated and showed that increases in the rupture force occurred in two stages, the early one (10–100 hr) being attributed to relaxation of fibers, and the long-term one (1000 hr) to oxidation of oil.

The static withdrawal force of single fibers was found to depend on length of withdrawn fiber, so results were expressed as force/unit length. The effect of compression of the sliver on the withdrawal force was similar to the effect on rupture force of sliver. The dynamic withdrawal force showed the same percentage increase with velocity as did the rupture force of corresponding sliver. Paper concludes by obtaining a relation between rupture force of sliver and single-fiber withdrawal force, assuming that first a straightening of fibers and then fiber slippage occurs. The rise in rupture force with increased testing speed is ascribed to the increase in load at a given extension, which is observed with single fibers as testing speed increases. The properties of the sliver thus appear to be controlled by single fiber behavior.

K. W. Hillier, England

2223. Yoshimura, Y., and Uemura, M., Yield condition of perfectly plastic solids and stress distribution (in Japanese), *Rep. Inst. Sci. Tech., Univ. Tokyo* **6**, 3, 149–156, June 1952.

Yield stress in mild steel is considerably higher when the stress distribution is not uniform, as in bending. To explain this phenomenon, Prof. Nakanishi's mean stress theory seems to be more reasonable than Cook's viewpoint of upper yield stress. As

the yield phenomenon will be considered to be dependent on the type of the stress distribution, yield condition of a perforated mild steel plate is investigated experimentally. Results obtained are as follows: In the case of an infinitely small hole, yielding occurs simultaneously over the whole section when the mean stress of the section reaches the lower yield stress, the stress on the periphery of the hole being 3 times the yield stress; in the case of an extremely large hole, yielding begins at the periphery of the hole when the local stress reaches 1.5 times the yield stress. For the intermediate dimension of the hole, the neutral yield condition between the above limiting cases is realized, which seems to be governed both by the stress concentration and the mean stress.

From authors' summary

2224. **Dumbleton, M. J., and Howlett, B. W., Yield points in bending experiments on zinc crystals,** *Proc. phys. Soc. Lond.* (*B*) 65, part 11, 395B, 882–886, Nov. 1952.

Previous experiments on yielding of zinc crystals containing nitrogen (Orowan, Wain and Cottrell) leave some doubt on whether strain aging is necessary for observation of yield points. Authors assume that absence of yield points in initial tension tests could arise from stress concentrations caused by handling of the very soft crystals, by grips, or by nonaxiality of loading. Therefore, experiments were done with a bending apparatus in which crystals of 1-mm diam, grown from melt in a quill and only pushed gently along the quill to a free part of about 5 cm, were loaded at the end of free part by a lever arm. High purity crystals showed no yielding tendencies, while commercially pure crystals demonstrated an inclination for yielding after loading and unloading at considerably lower stresses. These experiments confirm the above assumption and remove some difficulties in the interpretation of previous tensile tests. F. Wever, Germany

2225. **Clarebrough, L. M., Hargreaves, M. E., Michell, D., and West, G. W., The determination of the energy stored in a metal during plastic deformation,** *Proc. roy. Soc. Lond.* (*A*) **215,** 1123, 507–524, Dec. 1952.

A hollow specimen from a twisted copper bar was mounted in a special furnace beside an identical annealed one and kept at the same temperature as the other specimen and as the enclosure by an internal heater, while the temperature of the assembly was gradually raised. The integral of the difference in power input to the two specimens gave an accurate measure of the energy stored in the cold-worked specimen and its rate of release with temperature.

The stored energy increased continuously and at a slightly diminishing rate, with increasing torsional strain. The maximum rate of energy release occurred at lower temperatures for larger strains in a given material, or in a purer material for a given strain. J. D. Lubahn, USA

2226. **McLean, D., Grain-boundary slip during creep of aluminium,** *J. Inst. Metals,* **81,** 293–300, 1952/1953.

Grain-boundary displacements during creep at 200 C have been measured in seven super-pure aluminum specimens. The tests covered a range of grain-size from 1 to 9¼ grains/mm and of stress from about ⅓ to about ¾ ton/in.². The curves of grain-boundary displacement plotted against time resembled the corresponding extension/time curves. The fraction of the total extension due to the grain-boundary displacements was calculated. At a constant load of ½ ton/in.² this increased with decrease in grain size from about one fiftieth for 1 grain/mm to about one sixth for a grain size of 9¼ grains/mm. At constant grain size (4½ grains/mm) it increased with decrease in load, from about one fiftieth for a load of 1 ton/in.² to about one fifth for a load of ¼ ton/in.². A plot of grain-boundary displacement against extension due to crystal deformation is linear for all specimens, suggesting a linear interaction between these two quantities. A model for this interaction is proposed, and calculation shows it to agree with experiment within 2:1.

From author's summary

2227. **McLean, D., Crystal fragmentation in aluminium during creep,** *J. Inst. Metals* **81,** 287–292, 1952/1953.

Seven specimens of super-pure aluminum, having grain sizes of 1–9¼ grains/mm, were made to creep at 200 C under loads varying from about ⅓ to ¾ ton/in.²; the extensions produced ranged up to 50%. Observations and measurements were made relating to the subcrystals formed. These are consistent with a polygonization model for secondary creep and permit a quantitative check of this model to be made. Certain of the observations appear to be inconsistent with the theory of subcrystal formation advanced by Wilms and Wood [title source, **75, 79,** 693, 159; 1948–1949, 1951]. From author's summary

2228. **Rachinger, W. A., Relative grain translations in the plastic flow of aluminium,** *J. Inst. Metals* **81,** 33–41, 1952/1953.

Aluminum strip specimens were strained at various rates and temperatures and the grain size and equivalent strain of the grains were determined on the center section by counting the grain boundary interfaces along gage lengths in both the longitudinal and transverse directions. It was found that considerable grain growth had occurred at 350 C, whereas little, if any growth had occurred at 300 C and below. At 250 C and above, the grains were observed to be equiaxed, even where little grain growth had occurred. At 200 C and below, the grain elongation corresponded very nearly to the specimen elongation.

An ingenious analysis of measurements of the offsets in longitudinal and transverse grid lines ruled on the surface showed that much more grain deformation occurred at the surface than inside the specimen. This surface effect died out within 10 mils below the surface.

It is conceivable that the deformation could have resulted in equiaxed grains either by (a) grains sliding past one another as rigid bodies (except near the boundaries), or (b) grain deformation accompanied by recrystallization or boundary migration. The data do not distinguish between these two possibilities, but the author points out several arguments which one could offer in support of mechanism (a). J. D. Lubahn, USA

Failure, Mechanics of Solid State

(See also Rev. 2224)

2229. **Miklowitz, J., Elastic waves created during tensile fracture. The phenomenon of a second fracture,** *J. appl. Mech.* **20,** 1, 122–130, Mar. 1953.

Author presents analysis of elastic strain waves which occur after fracture of tension-test specimens. This analysis is used to explain the occurrence of a second fracture in tension tests of some brittle materials. The problem reduces to that of a vibrating cantilever beam in which longitudinal and flexural vibrations occur. The flexural vibrations are the result of the moment of the eccentric load that develops when fracture starts at the surface. Some experimental work on tension tests of Plexiglas and a high-speed steel is presented. However, little correlation is made between experimental and analytical results other than to show that double fractures frequently occur in some brittle materials.

P. G. Jones, USA

2230. **Walter, H., Effect of shrinkage and creep in composite beams** (in German), *Beton u. Stahlbeton.* **47, 5, 6;** 110–114, 132–137; May, June 1952.

Purpose of this paper is to investigate the significance of shrinkage and plastic flow of concrete to the initial stresses, induced through prestressing in a special type of composite beams used for roadway of steel and reinforced-concrete bridges. These beams are reinforced with heavy structural steel and have a thin concrete slab on top of steel beam, but have no concrete encasement.

The formulas for the computation of stresses in steel and concrete have been derived by means of theory of elasticity, and their application illustrated by examples of computations and diagrams. The formulas derived show how great is the influence of shrinkage and plastic flow.

Author presents some suggestions for the design. Reviewer believes that this paper is of interest for bridge designers, although the investigations, with regard to their completeness, are partly superseded by the latest investigations of German specialists and are dealt with in greater detail in the new book on the subject: Prof. K. Sattler, Techn. Univ. Berlin, "Theorie der Verbundkonstruktionen," 1953. J. B. Gabrys, USA

2231. **Vitovec, F., On the athermic plasticity and the notch effect in the lattice** (in German), *Öst. Ing.-Arch.* **6,** 4, 288–295, Sept. 1952.

Interrelation is discussed between possible approaches to atomic theory of plastic deformation, which has to account for large discrepancy between atomic strength or yield limit of perfect crystal lattice, and observed or technical strength: (a) Becker-Orowan theory based on Boltzman's equation, containing a stress-concentration factor of the order of 10^2 to 10^3 with respect to the acting shear stress; (b) Taylor-Polanyi edge-dislocation theory, specifying a type of lattice imperfection that produces a reduction of the right order of magnitude of the activation energy of relative motion of atomic planes. Author appears to be unaware of progress in the theory of dislocations attained in recent years in this country and in England. A. M. Freudenthal, USA

2232. **Terao, N., Refraction of shock waves due to the presence of fractures** (in French), *J. phys. Soc. Japan* **7,** 6, 631–633, Nov.-Dec. 1952.

A uniform dilatational stress was produced in a thin layer of resin melted on a metallic tray by rapid cooling. This layer of resin held on the tray was floated on the water and some mechanical shocks were given by electric discharges at two or three adjacent points near the bottom of the tray. The phenomena of the refractions of the cracks thus produced in the resin starting from each of these points were studied. At the places where $\alpha > 90°$ (α, angle between the direction of the crack starting from one of the sources A′ and that of the shock wave from the other source A), the cracks refracted toward the point A, while if $\alpha < 90°$, the cracks refracted in the direction diverging from the point A. The velocity of propagation of these cracks was estimated from the relation between the distances traveled by the crack and the shock wave. From author's summary

2233. **Polakowski, N. H., Effect of residual stresses on yielding and strain-ageing of carbon steel,** *J. Iron Steel Inst.* **172,** part 4, 369–376, Dec. 1952.

Author presents experimental results which show that, if residual stresses are present, the discontinuous yield point in carbon steels (0.05–0.72% C) is suppressed. This has been shown to be the case for the residual stresses induced by rolling, cold drawing, and torsional overstrain.

The residual stresses induced by torsional overstrain are shear stresses and not longitudinal stresses, as stated in the paper. These experiments add little new knowledge, the findings and theories presented having been accepted in practice for some time. J. A. Pope, England

2234. **Puzak, P. P., Eschbacher, E. W., and Pellini, W. S., Initiation and propagation of brittle fracture in structural steels,** *Welding J.* **31,** 12, 561s–581s, Dec. 1952.

Test has been developed for use with small plate samples simulating high elastic energy propagation of crack failures from small weld defects in large welded structures such as ships. Controlled explosion loading of a bulge-test-type plate containing preformed crack-starting weld defect is used. Results indicate brittle fracture propagates readily from small weld defects in ship plate at temperatures normally encountered by welded vessels. Correlation of these tests with actual welded-plate failures was good, but correlation with standard impact tests was significant only for completely brittle impact specimens.

A. N. Holden, USA

2235. **Bradway, R. D., Failure and defects encountered in the construction of welded ships,** *Welding J.* **31,** 12, 1111–1121, Dec. 1952.

Different types of cracks are classified as to origin and cause, with special emphasis on welding procedures, fabrication, workmanship, design, and materials. From author's summary

2236. **Rosenthal, D., and Woolsey, C. C., Jr., The effect of strain-rate on twinning and brittle fracture,** *Welding J.* **31,** 10, 475s–492s, Oct. 1952.

The relationships among strain rate, temperature, mechanical twinning, and brittle fracture for a low carbon steel were investigated experimentally in simple tension. Strain rates ranged from 0.02 to 275 reciprocal seconds, providing a 10,000-fold increase from the lowest to the highest strain rate. Threshold temperatures for the occurrence of twins and for brittle fracture were determined as a function of strain rate.

For the process of twinning, the results down to a temperature of about −170 F could be fitted by a reaction-rate equation with an activation energy of 4200 calories per mole. Below −170 F, the process of twinning was found to be relatively insensitive to strain rate.

Over the entire range of strain rates investigated, the process of brittle fracture was only slightly affected by strain rate. An increase of only 25 F in the transition temperature was found for a 10,000-fold increase in strain rate. Other investigators using notched specimens have reported larger effects of strain rate on transition temperature. The authors of the present paper suggest that the difference in strain-rate effect observed by them may be associated with the fact that unnotched specimens were used. The absolute values of the strain rates employed by different investigators should probably also be compared.

Theoretical considerations of the twinning process and of the occurrence of a critical temperature for twinning are included in the paper. Further work would be desirable on the effects of strain rate on brittle fracture, particularly from the point of view of relating the results of this investigation to previous investigations and of exploring possible relationships between twinning and the mechanism for brittle fracture.

W. T. Lankford, Jr., USA

Material Test Techniques

(See also Rev. 2222)

2237. **Britten, K. H. V., Compression tests on dural-celluboard sandwich panels,** *Aero. Res. Counc. Lond. Rep. Mem.* 2658, 18 pp., Nov. 1946, published 1952.

Results are given of compression tests made on 56 dural-celluboard sandwich panels with birch, spruce, or whitewood centers. These are compared with results from similar tests on dural-balsa sandwich and all-metal panels, and it is seen that over the range of sizes and weights considered, dural-celluboard can be equally or more efficient for carrying end loads.

The birch celluboard was more efficient than the spruce or whitewood and the thicker sandwiches, and those with thicker skins were more efficient than the thinner specimens. The maximum stress reached in the skin, 48,000 psi, was equal to the 0.1% tensile proof stress of the material. The birch filling had also reached its maximum compression stress, 8000 psi. The design had, therefore, exploited these materials to their fullest extent.

From author's summary

2238. **Winkler, F., Theory of burst tests on membranes** (in German), *Faserforsch. Textiltech.* **3,** 11, 449–458, Nov. 1952.

Balloon materials, which are strained in more than one direction, cannot be tested adequately by one-dimensional methods. A more realistic evaluation of strength can be obtained in a burst test. In one form of test, a circular sample is clamped over the end of a cylinder and inflated to rupture. By theory of elasticity for large deflections of a circular plate of isotropic material and negligible stiffness, author calculates maximum stress and strain (at center of sample) in terms of radius of sample a, pressure across sample p, and deflection of center of sample from initial position f. Author compares formulas with those of H. Sommer [*Melliand Textilber.* **22,** 414, 462, 516, 564, 1941], who made simplifying assumption that a distended sample has the form of a spherical cap. For $f/a < 0.4$, as is usually the case with woven fabrics, the sets of formulas agree well; but for larger f/a, as is often the case with films, they disagree seriously. Application of formulas is made to burst tests on synthetic films to show difference in results from the two sets of formulas, and to inflation tests to check predicted form of distended sample.

D. J. Montgomery, USA

2239. **Floyd, K. L., Second-order transition points in high polymers,** *Brit. J. appl. Phys.* **3,** 12, 373–375, Dec. 1952.

The transition temperature of high polymers was determined from the point where a break occurs in the linear-expansion-vs.-temperature curve. The expansion of the test material was magnified by an optical lever and measured by a Hilger Angle Dekkor. Temperature was controlled by adding dry ice to an alcohol bath. Mixtures of Hycar OR15 rubber and neoprene gave two transition temperatures—one characteristic of each of the pure rubbers. Buchdahl and Nielsen had previously shown such behavior to be characteristic of polymer mixtures in which the polymers are insoluble in one another [*J. appl. Phys.* **21,** 6, 482–487, 1950]. Such techniques may be used to analyze mechanical mixtures and copolymers. L. Nielsen, USA

2240. **Réti, P., Determination of microhardness by the new Soviet system** (in German), *Feingerätetech.* **1,** 6, 259–260, Sept. 1952.

The new Soviet system for microhardness testing uses a triangle-based pyramid diamond indenter instead of the square-based pyramids according to Vickers or Knoop. The reason is that, by using a triangle-based pyramid, it would be possible in principle to diminish the inaccuracies resulting from errors in the geometry of the pyramid apex, especially edge effects. Results from comparison tests on different materials show that the Russian method gives higher hardness numbers than the Vickers method, and this tendency is more obvious as the hardness of the test material increases. R. Nilson, Sweden

2241. **Phillips, A., Combined tension-torsion tests for aluminum alloy 2S-O,** *J. appl. Mech.* **19,** 4, 496–500, Dec. 1952.

Ten combined tension-torsion tests with thin-walled circular tubes of aluminum alloy 2S-O are described. All specimens were loaded with variable stress ratios. It has been found that the theory of plastic flow represents the experimental results with much greater accuracy than does the theory of plastic deformations. From author's summary

2242. **Neuweiler, N. G., The ultrasonics—definition, physical principles and applications in material testing** (in Spanish), *Rev. tech. Suisse* (*STZ*), no. 37, Sept. 1950 = *Cienc. y Técn.* **118,** 600, 248–270, June 1952.

Author published in *Rev. tech. Suisse*, Sept. 14, 1950, a paper of which this is a translation with some minor variations. Paper describes briefly the production and properties of ultrasonics, giving four methods of ultrasonic detection, of which only the echo method is now in practical use. A description of the Henry Hughes commercial instrument, taken from *J. Iron Steel Inst.*, March 1946, is given. As very few Spanish papers have been published on this subject, it is unfortunate that this one lacks theoretical basis. In general, the paper is a good introduction for Spanish readers; however, some of the wording seems unusual. For instance, the correct Spanish term is "ultra audible" instead of "ultra sonoro." L. Villena, Spain

Mechanical Properties of Specific Materials

(See also Revs. 2228, 2238, 2239, 2251)

2243. **Dudzinski, N., The Young's modulus, Poisson's ratio, and rigidity modulus of some aluminium alloys,** *J. Inst. Metals* **81,** 49–55, 1952/53.

Author has determined effects of 13 alloying elements on the elastic properties of aluminum-base alloys. Individual melts of binary, ternary, and quaternary experimental alloys were prepared, samples cast or forged, heat treated, and tested. Increase in Young's modulus and rigidity modulus values were generally proportional to the concentration of the alloying element, the rigidity modulus value increasing to a greater extent by a given alloying addition than the Young's modulus value. Author finds chromium had the greatest effect in increasing the value of Young's modulus (about 0.47×10^6 psi for 1 wt %), with titanium, vanadium, molybdenum, iron, tungsten, copper, and silver having a diminishing influence in the order named.

S. Goodman, USA

2244. **Ripling, E. J., Rheotropic embrittlement,** *ASTM Bull.* no. 186, 37–42, Dec. 1952.

Metals which do not crystallize in the face-centered cubic system exhibit an abrupt change in mechanical properties over a rather narrow testing temperature range (the transition temperature). The material is ductile and tough above this temperature and brittle below it.

This paper presents experimental data to show that this low-temperature brittleness can be cured, at least partially, by a judicious amount of cold working or prestraining at a super-transition temperature before testing or using it at the subtransi-

tion temperature. The author cites considerable experimental data of other investigators as well as his own to support this hypothesis. The materials discussed are 24S-T aluminum alloy, annealed silicon steel, low-alloy steel, and commercially pure zinc.

Of the various methods of prestraining, all the methods produced about the same result in the case of SAE 1340 steel, but prestraining zinc by extrusion produced results that were superior to those obtained by prestrain in tension. Y.-H. Pao, USA

2245. **Jackson, J. H., Slunder, C. J., Harder, O. H., and Gow, J. T., Resistance of cast Fe-Cr-Ni alloys to corrosion in oxidizing and reducing flue-gas atmospheres,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-37, 16 pp., 40 figs.

Attention is directed principally toward resistance of iron-chromium-nickel alloy castings against sulfur-containing gases, as the subject is of interest in varied fields such as furnaces, boilers, and gas turbines, where fuels containing sulfur are burned. Published papers are reviewed briefly before experimental setup is described. It is shown that corrosion of Fe-Cr-Ni alloys in oxidizing and reducing flue gases and gaseous atmospheres is a complex phenomenon. The selection should necessarily be based on data which reveal how metal beneath the surface is affected by corrosion, and not influenced entirely by values of rates of surface scaling or metal loss alone. Additions of silicon up to 2.5% and of aluminum up to 1% result in marked reduction of corrosion. In general, corrosion in the higher sulfur-bearing atmospheres was much less severe when the flue gas was oxidizing than when reducing. S. K. Ghaswala, India

2246. **Monypenny, J. H. G., Stainless iron and steel. Vol. 1. Stainless steels in industry, 3d ed.,** London, Chapman & Hall, Ltd., 1951, xii + 524 pp. 45 s.

This third revised edition by the late world-renowned authority on stainless steels is being presented in two volumes, of which this first volume is directed, as subtitle indicates, to industrial users. It is to be followed by another volume subtitled "Microstructure and constitution." Author avoids consideration of constitution diagrams and microstructures in the present volume, and consequently, in this reviewer's opinion, the volume loses somewhat in appeal to the metallurgist what it gains for the industrial user.

Successive chapters deal with: I. Stainless steels in commercial use; II. Working and fabricating stainless steels and the effects produced; III. How stainless steels resist corrosion; IV. Behavior at high temperatures—Heat-resisting steels; V. Selection of stainless steels for industrial purposes.

Although the book was published in 1951, the author had completed the manuscript in 1947, as judged by the date of his preface. Hence, many readers will be disappointed that the volume does not include some of the more recent developments, dealing, for example, with the sigma phase, with the precipitation-hardening alloys, or with the very low-carbon (0.30%) grades.

The present volume is extensively revised over the previous (1931) edition, but many of the illustrations appeared in the earlier edition; thus, the few photomicrographs that are included are of generally poor quality by present-day standards.

The book contains a wealth of practical information on nearly all aspects of stainless steels, and, in spite of minor criticisms like those expressed above, it deserves a prominent place in the library of all those interested in stainless steels. G. V. Smith, USA

2247. **Johnson, A. E., and Frost, N. E., Stress and plastic strain relations of a magnesium alloy,** *Engineer, Lond.* **194,** 5053, 713–719, Nov. 1952.

Extensive stress-strain data are given for thin-walled tubes machined from billets of a nominally isotropic magnesium alloy and tested at the National Physical Laboratory in a combined tension and torsion testing machine at 20, 100, and 150 C. The ratio of tension stress to torsion stress was held constant during each test, the constant ranging from 0.2 to 3.64. The specimens were loaded at a constant rate of increase in the octahedral stress. The data for tests at 20 C could be represented closely by a straight line in a plot of log σ_0 vs. log ϵ_0, where σ_0, ϵ_0 are octahedral stress and octahedral permanent strain, respectively. At 150 C there were large systematic deviations from the linear relation. These were ascribed to the development of anisotropy at the higher temperature. In support of this view, it is shown that the ratio of principal strains varied radically with increasing stress for the tests at 150 C, while it remained practically constant for the tests at the lower temperatures. No attempt is made, even in considering the results obtained at 150 C, to bring in time as a variable. W. Ramberg, USA

2248. **Waggett, G., The tensile properties of card and draw-frame slivers,** *J. Text. Inst. Trans.* **43,** 8, T380–T395, Aug. 1952.

A technique is described giving a criterion for evaluating the cohesion of a mass of fibers during processing, and the results are discussed.

Card- and draw-frame slivers have been submitted to tensile tests on a Cambridge extensometer with the jaws set apart at a distance slightly greater than the staple length. Typical load-extension curves for card slivers of a number of different materials are shown. The curves for cotton and wool are smooth while the curves for Fibro and other rayon fibers are stepped, showing the known "stick-slip" movement of the fibers which have been found in other laboratories. The stick-slip effect is shown to be dependent, in part, on the three-dimensional distortion (or kink) of the fibers and on the finishing. The magnitude of the load-extension curve is then examined.

The value of the breaking load has been found highly correlated with certain behavior in processing—examples are cited—and greatly dependent on the nature, concentration, and dispersion of the finish applied to the material. The form of the curve, giving for many finishes the frictional breaking force as a function of the quantity of finish adsorbed, is produced and the modification of this curve by increasing the acid chain length is studied.

The extension at the point of rupture is shown to be a function of the arrangement of the fibers in the slivers; the extension is increased with the kink for a card sliver and the extension is greater for a card sliver than for a draw-frame sliver of the same material. D. De Meulemeester, Belgium

2249. **Gilard, P., Jr., The problem of plane tension in window glass drawn vertically** (in French), *Rev. Univ. Mines* (9) **8,** 11, 426–437, Nov. 1952.

This article concerns the state of stress which arises in a sheet of glass which is formed by drawing the sheet vertically upward from a tank of molten glass. After a brief discussion of the pioneering work of Adams and Williamson, a qualitative treatment of the problem from a physicochemical point of view is developed. In this, the mechanism of the creation of internal stress is based on structural changes in the glass at a critical temperature, and this is applied directly to the particular problem of the drawing of window glass. The photoelastic method of measuring the stress distribution is discussed briefly. The article closes with a discussion of annealing to remove these stresses and a mention of several types of fracture that may occur. There is a bibliography to which should be added: P. Gerard and L. Troussart, "Tempering of plate glass," AMR **5,** Rev. 1746; G. Bartenev, "Research in tempering of glass," AMR **4,** 2072.

E. Saibel, USA

2250. **Sauer, J. A., and Hsiao, C. C., Stress crazing of plastics,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-100, 10 pp., 15 figs.

Authors review present knowledge of stress crazing of transparent plastics and indicate similarities with corrosion and stress cracking of metals and oxidation cracking of rubber. Solvent crazing is mentioned but attention is concentrated mainly on stress crazing.

Experiments are described in which polymethyl methacrylate and polystyrene are subjected to tensile stress to promote crazing, and tensile strengths before and after crazing are measured. A reduction to 55% of original strength is reported. No improved strength in crazed specimens was obtained by compressive stress applied before testing, though some healing of cracks was observed. By using protective coatings, authors have made measurements of rate of propagation of stress crazing from the surface of specimens of polystyrene under three different tensile loads. In the range considered (45%–65% original tensile strength), the rate is linear with applied load and constant with time of application of stress up to 1000 hr.

No contribution to theory of stress crazing is given. Recommendations to minimize occurrence of crazing are given and include the use of protective coatings and of minimum crazing stress rather than ultimate strength as limiting stress condition in design data.

K. W. Hillier, England

Mechanics of Forming and Cutting

2251. **Delpech, S. A., Structural properties and deformation of metals [Estructura y deformacion de los metales],** Buenos Aires, Libr. y Edit. Alsina, 1952, xv + 157 pp.

Thorough discussion of the subject is presented in three chapters. Ch. I: State of stress. Only the indispensable part of this subject is presented, with reference to Butty and Nadai for complete analytical treatment. Ch. II: State of solid crystals, including analysis of internal structure of metallic crystals, especially by x rays, and use of x rays for study of plastic deformation. Ch. III: Plasticity of metallic monocrystals, with special reference to research and publications by E. Schmid and W. Boas, includes discussions on plastic deformation of crystals, systems and elements of plastic flow, deformation due to translation of a monocrystal of zinc and aluminum, with theoretical (mathematical) derivations, double translation, representation of translation in a compact hexagonal system by standard stereographic projection, simple translation due to compression, dynamics of translation, critical tangential stress, mechanical consolidation and its graphical representation, critical normal stress, resistance against extirpation, tensile resistance, anisotropy and isotropy, rheology. Bibliography contains 58 references.

J. J. Polivka, USA

2252. **Letner, H. R., and Snyder, H. J., Grinding and lapping stresses in manganese oil-hardening tool steel,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-38, 15 pp., 14 figs.

The stress distribution resulting from grinding and lapping annealed manganese oil-hardening tool steel was investigated by studying the changes in curvature as thin uniform layers were removed from the specimen by lapping and chemical etching. These changes in curvature were observed by an optical interference technique which permitted the investigators to measure simultaneously the principal components of the biaxial surface stress.

As a result of the investigation, the following conclusions were made: The principal stresses lie parallel and perpendicular to the abrasive trajectories. The plastic deformation which causes these residual stresses is due to the externally applied forces as well as thermal stresses. Residual stresses resulting from the grinding operation fluctuate rapidly close to the surface, with its highest value confined to a layer of about 0.0001 in. The thickness of the layer in which plastic deformation occurred increased with the depth of cut, over the range tested. The residual stress induced by lapping is one of equal biaxial compression.

B. W. Shaffer, USA

2253. **Gilbert, W. W., and Boston, O. W., Power required by carbide-tipped face-milling cutters,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-53, 7 pp., 11 figs.

Paper contains experimental results of high-speed milling research projects of California Institute of Technology and University of Michigan. Curves are given showing relations between speed of cutting, feed, depth, width of bar, diameter of cutter, and hardness, all vs. power required. Text describes curves but not details of tests. No theory is considered. Typical computations are illustrated with alignment charts.

P. G. Hodge, Jr., USA

2254. **Holmquist, J. L., Investigation of the piercing process by means of model wax billets,** *Iron Steel Engr.* **29,** 12, 53–65, Dec. 1952.

The investigation was undertaken for the purpose of learning about the displacement and deformation of material which occurs when a solid round billet is converted to a hollow cylinder or "shell" by a Mannesmann-type piercing mill. The present report is mainly a description of the experimental technique and apparatus which have been developed. The technique has been applied to only the effect of the rate of reduction of section area on the magnitude and distribution of the deformations which occur in the piercing operation.

Conclusions are: The basic deformations which occur in piercing are the same regardless of material and are of the same magnitude in geometrically equivalent positions in geometrically similar models regardless of actual size. Redundant deformations of the same kind occur in piercing wax and steel, but they may differ in magnitude as a consequence of the difference in properties of the two materials. Although insufficient tests have been made to fully establish a relationship, it appears that wax may exhibit longitudinal shear to a greater degree than steel in piercing. A number of possibilities exist whereby closer correspondence might be obtained with respect to longitudinal shear. These are a different piercing temperature, a different piercing speed, or a different wax composition than were used in this investigation.

For useful results to be obtained, however, it is not essential that the redundant deformations be identical in magnitude in wax and steel. If a certain change in piercing conditions tends to alter a redundant deformation in wax, the same change in piercing conditions would tend to alter it in the same direction in steel.

It is only with respect to the redundant deformations that there can be any hope for achieving control. The basic deformations are inherent to the conversion of the solid billet to the hollow shell and cannot be altered or avoided.

The investigation of the rate of reduction on the redundant deformations did not reveal a simple pattern of relationship. The decelerated rate point gave the least twist with both 4- and 7-deg roll angles. The billets pierced with the points for 4-deg roll angle showed, as a group, less circumferential shear than those pierced with the points for 7-deg roll angle. It is uncertain, however, whether the lesser tendency toward circumferential shear can

be attributed to the difference in points, since these specimens as a group had greater wall thickness than the group pierced with the points for 7-deg roll angle. From author's summary

2255. **Strub, R. A., The theory of screw extruders,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 481–494, 1952. $6.

Considering plastics as being a Newtonian liquid, author develops some analytical solutions to the output, pressure, and power characteristics of the screw-extruding of plastics. Various cases are discussed, such as processes with and without leakage, plastics of constant and variable viscosity, and threads of different profiles. Theory of similitude is considered, and some comments on model and full-scale designs of screw extruders are made.

L. W. Hu, USA

Hydraulics; Cavitation; Transport

(See also Revs. 2308, 2328, 2337)

2256. **Binnie, A. M., The flow of water under a sluice-gate,** *Quart. J. Mech. appl. Math.* **5,** part 4, 395–407, Dec. 1952.

By introducing the Froude number of the flow, author simplifies relationship between conditions upstream and downstream of sluice gate. Well-known expressions are derived for alternate depth of flow, discharge, and force in the gate. A simple explanation is presented for the absence of waves on both sides of the gate. Coefficient of contraction C_c of the issuing flow is given as a review of experimental and theoretical investigations. Actually, author does not mention C_c, but presents instead the gate opening required to produce given Froude number. Furthermore, C_c given by Rouse ["Elementary mechanics of fluids," 1946] are not included. Reviewer feels that, although it does not contain new information, paper is a good clear compilation of present knowledge of the subject. W. D. Baines, Canada

2257. **Mongiardini, V., On the neglect of the variation of kinetic energy in the integration of the equation of steady motion** (in Italian), *Energia elett.* **29,** 9, 553–563, Sept. 1952.

Author gives expressions for errors obtained in solutions of backwater curves for uniform open channels when the effect of changes in the velocity head is neglected. It is shown that the changes in the velocity head cannot be neglected in the neighborhood of the critical depth. For channels of infinitely wide rectangular cross section and of infinitely wide and deep parabolic cross section an approximate formula is found which can be used to obtain the error in a simple manner.

P. Chiarulli, USA

2258. **Boreli, M., On the effect of an impermeable partial core on the flow through a dam** (in French), *C. R. Acad. Sci. Paris* **235,** 13, 646–648, Sept. 1952.

Electric analogy studies show influence of impermeable core with crest at lower elevation than upstream water level. Discharge, effective length of drain on downstream side of core, and velocity vary in function of core height. A. L. Jorissen, USA

2259. **Boreli, M., Use of a drain above an impermeable core in a dam** (in French), *C. R. Acad. Sci. Paris* **235,** 15, 785–786, Oct. 1952.

Study of effect of impermeable partial core on the flow through a dam (see preceding review) is extended to show practical interest of emergency drain upstream of impermeable core.

A. L. Jorissen, USA

2260. **Fil'chakov, P. F., The hydrodynamic computation of a weir with two notches of unequal length** (in Russian), *Ukrain. mat. Zh.* **2,** 92–109, 1950.

2261. **Rolfe, J. A. S., A new technique in tidal models,** *Bull. Liverpool Engng. Soc.* **26,** 5, 7–35, Dec. 1952.

Authors discuss difficulties in making recent tidal models, with periods greater than 200 sec, operate satisfactorily, whereas in the past the smaller models with periods less than 200 sec had generally performed well. Types of models pertinent to the discussion are those in which it was not desirable to greatly exaggerate the vertical scale, such as when piers and groynes are to be studied.

New technique suggested is applicable only when a short section of a tidal estuary is to be reproduced. If length of model is small compared to total length of estuary, the difference in surface level at the extremities resulting from surface gradients is likewise small. It is suggested under such circumstances that the Froudian law be dispensed with, and the velocity of flow be controlled independently of the tidal rise and fall of the surface level. With the velocity scale independent of the vertical scale, the former may be varied as required, i.e., verification of bed movement.

H. G. Farmer, Jr., USA

2262. **Pattantyús, G. A., and Terplˇn, Z., Method of operation and calculation of the hydraulic ram** (in German), *Acta Techn. Hung., Budapest* **5,** 4, 463–488, 1952.

Simplified equations for each phase of operating cycle of hydraulic ram are derived. Equations of motion of valves are solved, assuming head losses to be proportional to velocity head. Water hammer is analyzed in detail, and effect of elasticity of pipe is considered in computing wave celerity. Resulting equations are combined to give operating frequency and efficiency of the ram. Characteristic curves of a typical installation are computed, and relations between various types of waves discussed in detail. Mention is made of agreement with laboratory tests, but no detailed experimental verification of derived equations is given.

Reviewer believes paper is easier to follow and analysis simpler to use than that of J. Krol [AMR **5,** Rev. 1437]. Advantage of the latter paper is that it does have good experimental proof.

W. D. Baines, Canada

THE FOLLOWING PAPERS (REVS. 2263–2277) WERE PUBLISHED IN *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951, 4 vols. $48 per set.

2263. **Löfquist, B., Earth pressure in a thin impervious core,** vol. I, 99–109.

2264. **Jevdjevic, V. M., and Rajcevic, B. M., Some special features of designs and constructions for earth dams and rock-fill dams in Yugoslavia,** vol. I, 135–152.

In the first part of the paper, specific and technical conditions of earth dam and rock-fill dam construction in Yugoslavia are explained.

The second part of the paper deals with some characteristic features, such as the use of the grouting and control gallery under the impervious clay cores, two types of diaphragms, the application at the toes of ballast made of excavated material, the method of calculation and checking of the compactness of soil layers, and a method for dam construction in winter time.

From authors' summary

2265. **Harza, L. F., Rock-fill dams,** vol. I, 153–164.

This paper classifies rock-fill dams in four principal types which are fundamentally different as to materials used, leakage, main-

tenance, convenience of construction, relative stability, relative importance of settlement, etc. These types are: (a) Impervious diaphragm of concrete, steel plate, asphaltic materials, etc., on the water slope. (b) Center vertical thin core usually and preferably of earth. "Thin" is defined as having slopes steeper than the slope of repose. (c) Thick center core of earth with slopes equal to or flatter than the slope of repose. (d) Thin earth core dipping upstream toward the heel, instead of vertical, with the slope of its undercontact equal to the slope of repose of the rock fill upon which it rests. From author's summary

2266. **Blee, C. E., and Riegel, R. M., Rock-fill dams,** vol. I, 189–208.

This paper deals chiefly with that type of dam which consists of a central watertight core of earth enclosed and supported by fills of dumped rock on both sides of the core. Because the structural stability of the dam depends upon the rock fill, the authors consider it proper to classify this type as a rock-fill dam. Durability of materials and economy in construction are important factors favoring the type. Since the TVA has constructed four dams of this type, practices and standards have been developed which are set forth in the paper. From authors' summary

2267. **Bertram, G. E., Slope protection for earth dams,** vol. I, 209–221.

The principal factor affecting the performance of upstream slope protection is wave action. The wave heights are influenced by maximum sustained wind velocity, fetch, topographical conditions, and angle of wave attack. Observed wind and wave-height data, at best, were not too precise, but agreed reasonably well with calculated values.

Based upon survey results, minimum average rock sizes vs. maximum wave height for both dumped rock and hand-placed rock were developed. Data on Portland cement concrete, asphaltic concrete, and gravel were also collected and studied.

The importance of a properly designed filter layer under riprap including filter action of the riprap itself is clearly shown. From author's summary

2268. **Bennett, P. T., Notes on embankment design,** vol. I, 223–245.

2269. **Mayer, A., Some studies on earth and rock-fill dams at the soil mechanics laboratory** (in French), vol. I, 303–412.

The report sums up different studies made at the Laboratory because of faults occuring during the construction of earth and rock-fill dams. Two of these studies give valuable information as to the building of watertight screens. Others are described because of their exceptional character and for the observations which were made during the study. From author's summary

2270. **Ehrmann, P., and Guelton, M., Completed and proposed earth dams in the electricity system of France** (in French), vol. I, 431–446.

2271. **Girardeau, M., Rubble masonry dam foundations on alluvial deposits (Grandes Patures Dam)** (in French), vol. I, 447–474.

2272. **Pahud, G., Bia rock-fill dam (Lufira River, Katanga, Belgian Congo)** (in French), vol. I, 475–494.

2273. **Lee, F. M., Settlement and pore pressures of an experimental rolled-fill earth bank 55 feet high,** vol. I, 495–517.

This paper describes and discusses settlement and pore-pressure studies made on an experimental rolled-fill bank 55 ft high. The source of earth fill was soft decomposed sedimentary rock. This was placed and compacted by normal construction methods with close supervision.

To provide a background for the presentation of the experimental data, the design of the bank, materials of construction, construction methods, and control are first reviewed. The settlement measuring system and its installation are briefly described and the results discussed. The piezometer system and its installation are described. Typical data showing the pore pressures developed as a result of the construction, the percolation from the full reservoir, and the sudden drawdown of the reservoir are summarized. From author's summary

2274. **Lyse, I., Investigation on air entraining in concrete,** vol. III, 65–80.

This paper presents the results of an investigation of various air-entraining agents for concrete. Air entraining has been found to give considerable improvements in the durability of concrete exposed to freezing and thawing and is, therefore, of importance in all hydraulic structures exposed to frost action. The materials investigated consisted primarily of by-products from the Norwegian cellulose industry. These materials were compared with well-known air-entraining agents such as Vinsol resin and Darex. The results showed that the durability of the concrete was primarily affected by the amount of air voids in the concrete and only to a small degree influenced by the type of air-entraining agent. On the other hand, the compressive strengths of the concrete containing air-entraining agents were to some degree affected by the type of agent used. Low-cost material such as the Norwegian tallolje (pine oil), also called liquid resin, gave results well comparable to the results of Vinsol resin and Darex. From author's summary

2275. **Combe, Studies on freezing of concrete** (in French), vol. III, 271–283.

The present report describes the freezing-resistance tests made at the La Girotte Dam Plant Laboratory, now transferred to Bourg-Saint-Maurice (Savoie), for the construction of the Tignes Dam.

The tested pieces were submitted to a series of freezings at −25 C (−13 F), followed by a thawing in water heated to +20 C (+68 F). A cycle lasted one day.

They were then submitted to compression and bending rupture tests, and measurements were taken of permeability and resilience to impact. From author's summary

2276. **Lodigiani, P., Report on a few tests made to show the effect of granulometry on certain concrete characteristics and especially in relation to impermeability and swelling** (in French), vol. III, 511–517.

2277. **Nilsson, L. B., Temperatures, strains, and formation of cracks in concrete dam at Ljusne Strommar,** vol. III, 483–510.

Paper deals with measurements of temperatures and strains and observations of cracks in a concrete dam at Ljusne Strommar in Central Sweden. Measurements were made by means of resistance thermometers, strain meters, and joint meters.

All parts of the structure are constructed of concrete made from standard Portland cement, with the exception of a buttress of the non-overflow dam which is made of concrete with low-heat Portland cement for comparison.

The principal investigations were carried out on two buttresses of practically the same type. One of them was constructed of concrete made from standard cement, whereas the other was

executed in concrete made with low-heat cement. The measuring instruments fitted in these two buttresses were placed in the same relative positions.

Attempts were made to use the results of the measurements for a numerical comparison of the effects produced by the aforementioned types of cement on the risk of through-going cracks. However, the results of the measurements were found to be insufficient for this purpose. From author's summary

2278. Tsvetkov, P. K., Hydraulic calculation of a stilling basin in a channel expansion (in Russian), *Gidrotekh. Stroit.* no. 10, 38–41, Oct. 1952.

Solution of a channel expansion containing a stilling basin and of a channel with diverging walls is reviewed. Solution is restricted to a level bed and vertical walls. Preliminary model tests described are found to agree with theory. Graph is presented for determination of conjugate depths of hydraulic jump for channel with walls diverging at angle of 30° to center line. Literature cited includes five Russian-language articles.

M. W. Jackson, USA

2279. Stewart, H. L., Multiple pressures in a single hydraulic circuit, ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-46, 5 pp., 3 figs.

Certain types of hydraulic equipment employ multiple pressures in the same circuit to advantage. These are obtained by reducing and relief valves, individual pumps, and pressure intensifiers. Author discusses advantages of the various methods and possible difficulties in selection of improper system. Typical circuits for specific purposes are diagrammed and described.

W. DeLapp, USA

Incompressible Flow: Laminar; Viscous

(See also Rev. 2379)

2280. Kalinin, S. V., The discontinuous flow about an obstacle in the form of an arc of a second-degree curve (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 966–984, 1950.

2281. Dolapchiev, B., Application of the method of N. E. Kochin for the determination of the equilibrium of vortex streets depending on two parameters (in Bulgarian, with German summary), *Godishnik, Univ. Sofia, Fac. Sci. Livre* **1,** 46, 357–368, 1950.

2282. Gray, S., Fluid dynamic notation in current use at N.G.T.E., *Aero. Res. Counc. Lond. curr. Pap.* **97,** 20 pp., 6 figs., July 1950, published 1952.

This memorandum records and defines the current system of notation which is in general use, at the National Gas Turbine Establishment, for work on axial-flow compressors and cascade investigations in general, and which is being applied to some extent to the work on turbines. Heat-transfer and supersonic-flow aspects and other specialized treatments are excluded.

From author's summary

2283. Tatsumi, T., Note on discrepancies between two theories on the stability of plane Poiseuille flow, *J. phys. Soc. Japan* **7,** 6, 619–624, Nov.-Dec. 1952.

Existing theories of hydrodynamical stability of plane Poiseuille flow are divided into two groups by their quite different conclusions. Results attained by Lin and other earlier authors are that this flow is unstable for sufficiently large Reynolds numbers. On the other hand, Pekeris has obtained different results that flow is stable for any value of Reynolds number and that, in addition to ordinary disturbances discussed by earlier authors, there exists another class of perturbation.

In this paper, a critical survey of these conflicting results is presented. It is shown that Pekeris' first result arises essentially from the poor convergency of his series expansion, and that, if this procedure is avoided, existence of Lin's stability limit is asymptotically confirmed. It is also found that Pekeris' second prediction is erroneous.

From author's summary by A. Balloffet, Argentina

2284. Ertel, H., On the physical interpretation of functions appearing in the Clebsch-transformation of the hydrodynamic equations (in German), *S. B. dtsch. Akad. Wiss. Berlin, Kl. Mat. Nat.* no. 3, 19 pp., 1952. DM 1.50.

Let $v = \{\text{grad } \varphi + \lambda \text{ grad } \mu\}$ be the velocity field of a stationary flow of an ideal fluid with a definite pressure density relation. It is shown that one can take

$$\varphi = \int_0^t \left\{ \frac{v^2}{2} - \left(\Phi + \int \frac{dp}{\rho} \right) \right\} dt \quad \text{(action)}$$

$$\lambda = \frac{v^2}{2} + \Phi + \int \frac{dp}{\rho} \quad \text{(energy)}$$

$$\mu = t - \theta \quad \text{(time interval)}$$

(Φ is the potential energy). The integral is taken along the particle path, θ is the time at which the particle crosses a surface orthogonal to all streamlines. Some earlier results are deduced from these formulas. L. J. F. Broer, Holland

2285. Ippen, A. T., and Harleman, D. R. F., Steady-state characteristics of subsurface flow, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 79–93, 1952. $1.75.

Analysis of experiments is presented concerning the flow of a fluid underneath a layer of another fluid, differing from the former in viscosity and density.

Velocity distribution and resistance for laminar uniform underflow are given in the two-dimensional case with the limitation imposed by the bottom boundary [see Lock, AMR **4,** Rev. 3642, for vertically unlimited layers]. Side-wall effects in evaluation of experimental results are treated with the usual rough hydraulics approximation.

Stability of the interface is characterized by the ratio F between mean velocity and propagation velocity of small disturbances. At the limit of stability, i.e., conditions at which internal waves break, F is compared with theoretically deduced [Lamb, "Hydrodynamics," Ch. IX] and observed wave length.

Stability criterion of Keulegan [AMR **3,** Rev. 925] is reduced to a function of F and a Reynolds number R. At the stability limit, F is postulated to be constant, and the critical value of the Keulegan criterion is shown to be dependent on R in the laminar range.

Form of a surge front in a density current is presented in a dimensionless diagram without analytical comment, for which authors refer to M.S. theses of the M.I.T.

H. J. Schoemaker, Holland

2286. Kuznetsov, M. D., Hydrodynamics of an eccentric ring section (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **85,** 4, 715–717, Aug. 1952.

Fully developed laminar flow through the space between an outer circular tube and an inner eccentrically placed tube is con-

sidered. Dependence of velocity upon polar angle is introduced through boundary conditions but neglected in the differential equation. Then, for small inner tube at large eccentricities, author obtains less pressure drop than for no inner tube. The sophomoric contradictions make the reviewer wonder why the paper was accepted for publication. M. V. Morkovin, USA

2287. **Patterson, G. N., An introduction to the general equations of fluid dynamics,** *Inst. Aerophys. Univ. Toronto, Rev.* no. 3, 73 pp., Dec. 1950.

A derivation of the general equations of motion of fluid dynamics, including compressibility and viscosity, is given. Author makes use of vector notation, and the greater part of the article is devoted to development of adequate portion of vector analysis, including a discussion of usual types of orthogonal coordinates. At the end, a short discussion of similarity rules is given. This survey, though classic in content, may have value for students having some general knowledge of the subject.

A. van Heemert, Holland

2288. **Targ, S. M., Fundamental problems of the theory of laminar flow [Osnovníe zadachi teorii laminarníkh techenii],** Moscow-Leningrad, Gos. Izd. Tekh.-Teor. Lit., 1951, 420 pp., 15.85 rubles.

This book is primarily a collection of various solutions or approximate solutions of the Navier-Stokes equations for special boundary conditions. Although it is not aimed at being encyclopedic in this respect, it covers most of the types of problems occurring in applications and includes several new solutions. Problems of special interest to mathematicians, such as existence and uniqueness of solutions for more general boundary conditions, are not discussed. Although a large part of the book is given over to approximate solutions, the pertinent exact solutions are usually given in each chapter, generally at the beginning. The chapter headings are as follows: (1) The equations of motion of an incompressible viscous fluid. (2) The simplest steady flows of a viscous fluid bounded by rigid walls. (3) Unsteady flows of a viscous fluid bounded by rigid walls. (4) Steady flow in a boundary layer. (5) Unsteady flow in a boundary layer. (6) Development of viscous flow in tubes. (7) Viscous flow in diffusers. (8) Flow of a viscous fluid in a lubricating film. (9) Some heat-exchange problems for motion of a viscous liquid. J. V. Wehausen, USA

2289. **Miles, J. W., A note on the damping in roll of a cruciform winged body,** *Quart. appl. Math.* **10,** 276–277, 1952.

Author applies Ward's slender-body theory to the calculation of the damping in roll of a slender body of revolution bearing cruciform wings. The potential is obtained through conformal mapping of the cross-sectional profile of the cruciform winged body to a circle. Then the integral of rolling moment is solved. In the limiting case, the solution checks with some known results.

C. C. Chang, England

2290. **Hopf, E., On the initial conditions of the fundamental hydrodynamic equations** (in German), *Math. Nachr.* **4,** 213–231, 1951.

In his researches [(A) *J. Math. pures appl.* (9) **12,** 1–82, 1933; (B) ibid. **13,** 331–418, 1934; (C) *Acta math.* **63,** 193–248, 1934] on the integrals of the Navier-Stokes equations

$$\frac{\partial u_i}{\partial t} + u_\alpha \frac{\partial u_i}{\partial x_\alpha} = -\frac{\partial p}{\partial x_i} + \mu \frac{\partial^2 u_i}{\partial x_\beta \partial x_\beta}, \quad i = 1, 2, 3 \qquad [1]$$

(defining the motion of an incompressible viscous fluid), J. Leray introduced the following ideas: (a) The three components u_i of the velocity at every time $t \geqq 0$ belong to L^2 with respect to x (the kinetic energy is finite); (b) the equations [1] are replaced by the integrodifferential equations of C. W. Oseen, which no longer contain the derivatives of second order with respect to x_i; (c) the derivatives of first order with respect to x_i could fail to exist, at least at certain times, and should be replaced by quasi-derivatives [whose definition is given in (C)]. In this paper, the author replaces (a) by the assumption that all functions involved belong to L^2 with respect to (x, t) and, by an elegant use of functions equal to zero outside of a bounded domain, replaces the integrodifferential equations of Oseen by new ones in which the derivatives of first order of x_i have disappeared, as well as the derivatives of second order. He considers an open domain $\hat{G}$ in the four-dimensional space (x, t) and the (real) Hilbert space H of all square-integrable functions in $\hat{G}$; he says that a vector field belongs to class N if it is equal to 0 outside of a compact set in $\hat{G}$; he then replaces equations [1] by

$$\int_{\hat{G}} \left[\frac{\partial a_i}{\partial t} u_i + \frac{\partial a_i}{\partial x_\alpha} u_\alpha u_i + \mu \frac{\partial^2 a_i}{\partial x_\beta \partial x_\beta} u_i \right] dx dt = 0 \qquad [2]$$

which must be satisfied for all vector fields $a_i \in N$ (and smooth enough). The class $H'(N)$ is defined by: $g(x, t) \in H'(N)$ if it is the limit of a weakly convergent sequence of functions $\gamma^{(n)}(x, t)$ belonging to N, having quasi-derivatives, the norm of the $\gamma^{(n)}$ and of their quasi-derivatives being uniformly bounded. Take the particular case in which $\hat{G}$ is a cylinder set: $x \in G$, $0 < t < T$ where G is an arbitrary domain in the x space, and define a class $H(N)$ in G in the same way as $H'(N)$ in $\hat{G}$. Obviously, the fact that $g(x, t) \in H'(N)$ implies that at every time t in the interval $0 < t < T$, $g(x, t) \to 0$ (in some generalized sense) when x converges to the boundary of G.

The main result of the present paper is the following existence theorem: Given a vector field $U_i(x)$ in G, satisfying the incompressibility condition and belonging to $H(N)$; there exists a vector field $u_i(x, t)$ in $\hat{G}$ with the following properties: (α) $u_i(x, t) \in H'(N)$; (β) $u_i(x, t)$ satisfies the equation [2]; (γ) $u_i(x, t)$ converges strongly toward $U_i(x)$ if $t \to 0$. This theorem defines thus a "flow" of the fluid in G in a generalized sense (because the derivatives of the u_i do not need to exist), satisfying the given initial condition [property (γ)], the fluid being at rest on the boundary of G [property $H'(N)$].

J. Kampé de Fériet, France

2291. **Byushgens, S. S., On streamlines. II** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 5, 861–863, June 1952.

Author established in a preceding publication [AMR **5,** Rev. 1773] conditions of congruence for the streamlines in a steady ideal and incompressible fluid motion. The same results are now gained by a slightly different, purely geometrical method.

W. Wuest, Germany

2292. **Squire, H. B., Some viscous fluid flow problems. I: Jet emerging from a hole in a plane wall,** *Phil. Mag.* (7) **43,** 344, 942–945, Sept. 1952.

In previous paper [AMR **5,** Rev. 1122], author reduced exact equation for stream function ψ of an axial symmetrical-viscous flow in spherical coordinates (r, θ, φ) to an ordinay differential equation assuming a simple form $\psi = \nu r f(\mu)$, $\mu = \cos\theta$

$$f^2 = 4\mu f + 2(1 - \mu^2)f' + A\mu^2 + B\mu + C \qquad [1]$$

Transforming [1] by standard methods into a hypergeometric equation, exact solutions could be found.

A particular case was considered, physically interpreted as a jet emerging normally to a plane wall (slipping along wall) or,

more accurately, as a flow, caused by a concentrated force F at point of wall in direction of jet. Streamline pattern is drawn in three cases, corresponding to two finite values of F and to the limiting case of infinite F (high speed or infinitely thin jet).

R. Timman, Holland

Compressible Flow, Gas Dynamics

See also Revs. 2232, 2314, 2315, 2316, 2317, 2319, 2330, 2334, 2339, 2340, 2357)

2293. Keilson, J., and Storer, J. E., On Brownian motion, Boltzmann's equation, and the Fokker-Planck equation, *Quart. appl. Math.* **10,** 3, 243–253, Oct. 1952.

In the treatment of Brownian motion based on Langevin's equation, moments higher than the second vanish and the Fokker-Planck equation is obtained. The latter equation is an unsatisfactory description when the dispersion is small. Authors consider the exact treatment of Brownian motion based on the Boltzmann integral equation. This is solved by the substitution of a suitable scattering kernel, and the solution is compared with that of the corresponding Fokker-Planck equation. It is found that, when the mass ratio of the particles is high and the dispersion great, the Fokker-Planck equation is perfectly adequate. Even when the dispersion is small the first and second moments of the F-P solution are reliable; the higher moments, however, are then in considerable error—an error which becomes negligible as the dispersion increases. L. M. Grossman, Holland

2294. Gullstrand, T. R, The flow over two-dimensional aerofoils at incidence in the transonic speed range, *Roy. Inst. Technol. Div. Aero., Stockholm, KTH-Aero TN* 27, 25 pp., Oct. 1952.

This is an extension of Oswatitsch's transonic integral equation to thin airfoil at small angle of attack. An approximate procedure is developed to calculate the antisymmetrical change in velocity caused by shifts of locations of normal shocks. For a given example of thin symmetrical airfoil of parabolic ares, the lift-curve slope as a function of free-stream Mach number is investigated and is found to agree with available experimental data.

C. C. Chang, England

2295. Broer, L. J. F., On the theory of shock structure I, *Appl. sci. Res.* (*A*) **3,** 5, 348–360, 1952.

Author expands Navier-Stokes and Burnett equations for a steady plane shock wave in powers of a shock strength parameter $\epsilon = (v_1 - v_2)/(v_1 + v_2)$. Prandtl number is assumed constant and equal to 3/4, but the viscosity is a power function of the temperature. Calculation of the reflectivity of the shock front shows no effect of the Burnett terms, and author concludes that reflectivity measurements, such as those of Greene, Cowan, and Hornig [AMR **5,** Rev. 475], do not provide a suitable means of determining the effect of the Burnett terms on shock structure.

The numerical value author gets for K in Eq. 28 is incorrect. He uses the value 45/8 for θ_2, as given in the book of Chapman and Cowling, without realizing θ_2 and θ_5 are both given incorrectly [see AMR **5,** Rev. 483, or *NACA TN* no. 2895, or APL/JHU CM-443]. Since the correct value of θ_2 is $-45/8$, the value of K is -0.11, and author's conclusion on the shape of the velocity profile is invalid.

Reviewer believes author's theory is only one of many attempts to discuss shock structure under the a priori assumption that the shock strength is weak; and without comparison with other theories of Thomas, Wang Chang, Mott-Smith, Zoller, or Grad [AMR **5,** Rev. 474; AMR **6,** Rev. 972], it is not clear whether author's approach is significantly different from Mrs. Chang's.

R. E. Street, USA

2296. Chester, W., The decay of shock waves, *Quart. J. Mech. appl. Math.* **5,** part 4, 408–422, Dec. 1952.

The asymptotic decay of one-dimensional unsteady shock wave caused by preceding and following rarefaction waves is investigated by neglecting entropy changes and by ignoring all terms of third order in the shock strength.

F. Schultz-Grunow, Germany

2297. Tumashev, G. G., Construction of channels and nozzles with a given distribution of the subsonic velocities along the walls (in Russian), *Izv. Kazan. Filial. Akad. Nauk SSSR Ser. Fiz.-Mat. Tekh. Nauk* **1,** 47–50, 1948.

The equations for steady plane irrotational flow can be written as $\partial s/\partial\psi = -K^{1/2}\partial\beta/\partial\varphi$, $\partial\beta/\partial\psi = -K^{1/2}\partial s/\partial\varphi$, where

$$K = (1 - \lambda^2)[1 - \lambda^2(\gamma - 1)/(\gamma + 1)]^{(1+\gamma)/(1-\gamma)}$$

$$\lambda ds/d\lambda = \{(1 - \lambda^2)/[1 - \lambda^2(\gamma - 1)/(\gamma + 1)]\}^{\frac{1}{2}}$$

β is the inclination of the velocity relative to the x-axis, λ is the speed of flow in units of the critical speed of sound, φ is the velocity potential, and ψ the stream function. For small λ, the author replaces K by 1, and then $s - i\beta$ is an analytic function of $\varphi + i\psi$. For an infinite channel with s prescribed as a function of arc length ϵ along the wall, the problem reduces to determining $s - i\beta$ with given boundary values $s = s(\varphi)$ on the edges of the strip $0 \leqq \psi \leqq \frac{1}{2}\pi$. The channel walls are given by $x + iy = \int e^{i\beta}d\epsilon$ on $\psi = 0$ or $\frac{1}{2}\pi$. For a finite channel joining two regions of parallel flow, the problem reduces to determining $s - i\beta$ on a rectangle with given boundary values $s(\varphi)$ on $\psi = 0$ or ω_2, and $\beta = \text{const}$ on $\varphi = \pm\frac{1}{2}\omega_1$. J. H. Giese, USA

2298. Tumashev, G. G., Construction of a nozzle according to the distribution of supersonic velocities along the walls (in Russian), *Izv. Kazan. Filial. Akad. Nauk. SSSR Ser. Fiz.-Mat. Tekh. Nauk* **2,** 133–134, 1950.

For the stream and velocity potential functions of nonlinearized plane supersonic flow, Christianovich [*Prikl. Mat. Mekh.* **11,** 215–222, 1947; also *Amer. math. Soc. Transl.* no. 10, 1950] has developed approximations involving two arbitrary functions of single characteristic variables. The author has applied these to determine the boundaries of a channel from a knowledge of the velocity as a function of one characteristic variable on a characteristic AB and the speed as a function of arc length on the streamlines through A and B. He also shows that this problem can be solved by a graphical method of characteristics.

J. H. Giese, USA

2299. Garcia, G., On the integration and properties, and the integral curves of the complete diffusion equation (in Spanish), *Actas Acad. Ci. Lima* **15,** 3–24, 1952.

The complete diffusion equation referred to is

$$D \cdot \Delta_2 u - \text{div}\,(\mathbf{v}u) + F(u) = u_t$$

where D is constant, u a concentration and $0 < u < 1$. The author first considers the slightly different case where $\mathbf{v} \equiv 0$ and $F(u)$ is replaced by $(a + b\epsilon(t))u$, with a and b constant. He surveys various methods of integration. The complete equation is considered mainly in one dimension with $\mathbf{v} \equiv 0$. Various forms of $F(u)$ are suggested, some of which ultimately lead to an ordinary differential equation which can be integrated.

Courtesy of Mathematical Reviews W. Feller, Sweden

2300. **Duff, R. E., The interaction of plane shock waves and rough surfaces,** *J. appl. Phys.* **23,** 12, 1373–1379, Dec. 1952.

Effect of surface roughness on normal shock waves was determined by shock-tube experiments. Two- and three-dimensional roughnesses were used, with pressure ratio of normal shock varying from 0.1 to 0.9. Curves for different shock strengths and roughness sizes show rate of shock retardation and space rate of energy dissipation (latter quantity not clearly defined). Curvature of normal shock near surface was found to depend on surface roughness, length of roughness traversed, and shock strength. Results suggest that shock retardation and energy dissipation are results of shock diffraction around particles on surface rather than of viscous effects. A. H. Shapiro, USA

2301. **Comolet, R., Radial flow between two parallel planes of a compressible viscous fluid** (in French), *C. R. Acad. Sci. Paris* 235, 20, 1190–1193, Nov. 1952.

The Navier-Stokes equation is combined with the continuity equation for steady flow, neglecting inertia forces and assuming source flow between two planes. The distance between the two planes is assumed small with respect to the radius r. The variation of the radial velocity with r is basically parabolic, but the curve shape changes with large distance from the source. The mass rate of flow is first calculated in terms of dp/dr where p is the pressure, and then, in finite form, by assuming $p/p_0 = (\rho/\rho_0)^n =$ constant, as function of the pressure ratio; the viscosity is assumed constant. Author notes that his equation for mass rate of flow has common properties with incompressible results if the pressure changes are small; for large pressure changes, however, compressibility effects become important.

G. R. Graetzer, USA

2302. **Comolet, R., Experimental study of the radial flow of a viscous fluid between two parallel planes** (in French), *C. R. Acad. Sci. Paris* **235,** 22, 1366–1369, Dec. 1952.

Author had calculated the mass rate of flow in a previous paper (see preceding review) under the assumption that $p/p_0 = (\rho/\rho_0)^n$. With a flow meter and micromanometer, he now determines the mass rate of flow experimentally and finds good agreement for $n = 1$ and $n = 1.41$. The effect of changing the infinitesimal distance between the parallel planes is then investigated with an interferometer; the agreement with theory is slightly less satisfactory due to residual air flow on the rough surfaces. However, the theoretical formula is well applicable for laminar flow. The interesting experiments are carried out for sources passing through 0.7-mm holes and for plate diameters of 9.4 mm and 1.7 mm. G. R. Graetzer, USA

2303. **Vincenti, W. G., and Wagoner, C. B., Theoretical study of the transonic lift of a double-wedge profile with detached bow wave,** *NACA TN* 2832, 63 pp., Dec. 1952.

Paper is third in a series [see also AMR **4,** Rev. 4530; **5,** Rev. 2106] using transonic small disturbance theory to compute aerodynamic characteristics of double-wedge profile with detached bow wave. Solution for lift-curve slope is obtained as perturbation on zero-angle-of-attack solution. Relaxation methods and characteristics method are used for mixed-flow and supersonic-flow regions, respectively.

Results indicate that, for inviscid flow, no marked changes in characteristics of airfoil section take place as free-stream Mach number passes through 1. Variation with Mach number is most rapid in vicinity of shock attachment. Plotted results give chordwise lift distribution, lift-curve slope, and center of lift as functions of the transonic similarity parameter.

L. L. Cronvich, USA

2304. **Cabannes, H., Study of the curvature at the vertex of an attached shock wave in plane nonstationary flow** (in French), *C. R. Acad. Sci. Paris* **235,** 14, 698–700, Oct. 1952.

The problem considered in this instance is that of a uniform supersonic flow past a point body which is rotating about its leading edge. The analysis is given in abstract and cannot therefore be reviewed, but the method involves power-series expansions in terms of r, the distance from the leading edge, of the velocity components, density, and pressure. It is concluded that by modifying the angular velocity of rotation, one can obtain any value, positive or negative, for the curvature of the shock at the leading edge. There are, however, two particular settings of the body for which the curvature is infinite. A. D. Young, England

2305. **Pai, S. I., On the flow behind an attached curved shock,** *J. aero. Sci.* **19,** 11, 734–742, Nov. 1952.

The supersonic flow behind curved shocks can be calculated numerically by the method of characteristics. In order to obtain more general conclusions and, furthermore, to calculate the subsonic flow behind curved shocks, author presents an analytic method. He starts from the differential equation for the stream function ψ of the rotational flow. The linearization of his equation is accomplished by assuming the development $\psi = \psi_0(x,y) + \psi_1(x_1y) + \psi_2(x_1y) + \ldots$, where ψ_0 is a certain known solution for irrotational motion. Assuming ψ_0 as a uniform flow, the first-order linearized differential equation of a stream function leads to the so-called Sears equation, which is solved for the flow over a plane ogive behind an attached curved weak or strong shock. The velocity field can be divided into three components—i.e., one is due to the basic disturbances from the surface of the ogive; the second is due to the reflected disturbances from the shock front; and the third is due to vorticity. In the case of weak shock, there are two points where the first-order linearized theory fails and in the neighborhood of which the method of characteristics may be applied. W. Wuest, Germany

2306. **Nozdrev, V. F., Ultrasonic velocity in saturated vapors of organic fluids** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85,** 4, 777–779, Aug. 1952.

A brief discussion is given of the errors involved in the use of an interferometer to measure the sound velocity of gas in the critical region. The paper reports experimental measurements of sound velocity by an optical method for seven organic vapors in the temperature range 100 to 300 C. In each case, the value of the sound velocity decreases with increasing temperature—slowly at first, and then more rapidly as the critical point is approached. Values of the adiabatic compressibility for both the liquid and vapor phase are also presented. The velocity measurements are shown to satisfy a theoretical expression which can, in turn, be used to determine the specific heat ratio γ. The velocity measurement is suggested as a useful method for such a determination. R. T. Beyer, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 2167, 2288, 2357)

2307. **Sato, H., Experimental study of the spectrum of isotropic turbulence, III,** *J. phys. Soc. Japan* **8,** 1, 82–87, Jan.-Feb. 1953.

[For parts I and II see AMR **5,** Rev. 1837; **6,** Rev. 1009.] In order to clarify the detailed structure of turbulence, measurements were made on the fluctuation of spectral component which is the output of band-pass filter. Using a voltage integrator and a counter-chronograph, two quantities were observed in the so-

called isotropic turbulence produced by a grid in a wind tunnel.

One is the distribution function of amplitude averaged in a certain time interval. Dispersions of distribution under various experimental conditions are computed and compared. The other is the time correlation function of fluctuating output. The magnitude of correlation is not so small even for a time interval of 0.5 sec, and curves seem to be classified into two groups according to the central frequency. From author's summary

2308. Abramson, A. E., Investigation of annular liquid flow with cocurrent air flow in horizontal tubes, *J. appl. Mech.* **19,** 3, 267–274, Sept. 1952.

Shadowgraph pictures are presented of the injected liquid-film surface under varying conditions. The influence of air-mass velocity, air temperature, tube diameter, liquid surface tension, and liquid viscosity on the surface appearance is observed. Approximate film-thickness calculations, assuming the air flow as replaced by a fictitious flow of the same fluid as in the annulus, support strong evidence that transition from a smooth into a disturbed more or less wavelike surface occurs when the liquid thickness enters a flow region where turbulence forces predominate over the viscous forces.

Yap Kie Jan, Holland

2309. Shibuya, I., Theoretical study of the turbulent transition of a flow through a circular pipe, *Rep. Inst. high Speed Mech., Tôhoku Univ.* (B) **1,** 37–46, 1951.

To examine the stability of the Poiseuille pipe flow, author applies the method of small disturbances. He assumes a three-dimensional motion of disturbance as a periodic function of the time, the axial direction, and the center angle. The viscosity is considered to be effective only near the wall. This second boundary layer is very small compared with the pipe radius. The mathematical treatment of the eigenvalue problem gives a critical Reynolds number of about 300.

Using a motion of disturbance independent on the center angle, the basic flow becomes stable for all Reynolds numbers. In this case, author's treatment coincides with Th. Sexl's investigation [*Ann. Phys.* **83,** p. 835, 1927]. N. Scholz, Germany

2310. Alad'ev, I. T., Experimental determination of local and average heat-transfer coefficients for turbulent flow of liquids in pipes (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 11, 1669–1681, Nov. 1951.

Because of the lack of methods giving satisfactory results concerning the effect of tube length upon the heat-transfer coefficient for fluid in turbulent flow, author has carried out an extensive investigation in this field, some results of which are given in this paper.

It is found that, in developed turbulent flow, the local heat-transfer coefficient α_x decreases with increase in the distance x from the entrance, so far as the ratio x/d is smaller than a determined value depending on the Reynolds number Re_x. However, when $x > 40\,d$, then α_x practically is independent of x for all Re_x.

The average coefficient of heat transfer α is decreasing when the relative length l/d of the tube increases. So far as $(l/d) < 50$, α is a decreasing function of Re; for $(l/d) > 50$, the coefficient α practically is independent of l/d for all values of Re.

The results are compared with those of other authors.

J. Beránek, Czechoslovakia

2311. Van Driest, E. R., Calculation of the stability of the laminar boundary layer in a compressible fluid on a flat plate with heat transfer, *J. aero. Sci.* **19,** 12, 801–812, 828, Dec. 1952.

The Lees-Lin theory [AMR **3,** Rev. 1548] is used to determine the cooling necessary to stabilize completely a laminar boundary layer in supersonic flow under zero pressure gradient. The distributions of mean quantities across the boundary layer are found by Crocco's method [AMR **5,** Rev. 2903]. Stability is shown to be appreciably affected by the Prandtl number and the viscosity-temperature law. For a Prandtl number of 0.75 and the Sutherland viscosity law, the calculations suggest that, above Mach numbers of 9, stability cannot be completely effected by cooling, owing to the local angular momentum in the boundary layer always having a maximum where subsonic disturbance velocities are possible. Curves of critical Reynolds number for various wall temperatures and free-stream Mach numbers are given. No arguments are provided to show that the extension of Lees' approximate formulas to higher Mach numbers and lower wall temperatures is permissible. A. F. Pillow, Australia

2312. Krzywoblocki, M. Z., On the invariants in the turbulence in compressible viscous fluids, Heat Transf. Fluid Mech. Inst., Stanford Univ. Press, 65–71, 1952 = *J. Franklin Inst.* 254, 4, 317–322, Oct. 1952.

Loitsianskiĭ derived the invariant disturbance moment in a homogeneous isotropic turbulent flow of an incompressible viscous fluid. In the present note, the author derives some moments in a homogeneous isotropic turbulent flow of a compressible viscous fluid. From author's summary

Aerodynamics of Flight; Wind Forces

(See also Revs. 2166, 2210, 2343)

2313. Carpentier, J., Frequency response analysis for aircraft (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 241–264, 1952.

Author gives a simple review of the application of transfer-function theory to aircraft response, summarizing the wind-tunnel and flight-testing techniques employed. The transfer function locus is plotted for both longitudinal and lateral oscillations, and the physical characteristics of the response of the aircraft are linked to the stability characteristics.

While there is little new work in this paper, reviewer feels that the presentation and physical interpretations should be very helpful to newcomers in this subject. A. W. Babister, Scotland

2314. Young, A. D., and Owen, P. R., Note on the influence of aspect ratio on the variation with Mach number of the lift and hinge-moment characteristics of a wing and full-span control, *Aero. Res. Counc. Lond. Rep. Mem.* 2767, 5 pp., Aug. 1943, published 1952.

Linearized theory is used to show that the effects of compressibility ($0.2 \leq M \leq 0.8$) on lift and hinge moments of full-span control surfaces are functions of aspect ratio ($3 \leq AR \leq 8$). Reduction in aspect ratio materially reduces the increases, due to Mach number, of the lift variation with angle of attack, control-surface deflection, and tab deflection. The same effect is noted for the variation in hinge moment with angle of attack, while the hinge-moment variations with control surface and tab deflection in many practical cases are only slightly influenced by the aspect ratio. H. P. Liepman, USA

2315. Lagerstrom, P. A., and Graham, Martha E., Some aerodynamic formulas in linearized supersonic theory for damping in roll and effect of twist for trapezoidal wings, *Douglas Aircr. Co., Rep.* SM-13200, 43 pp., 1948.

Rolling moments and lift distributions for trapezoidal wings are calculated by assuming that effect of roll is equivalent to twisting

wing in steady flow. General problem of wing with spanwise variation of angle of attack is also considered.

G. N. Ward, England

2316. **Graham, Martha E., Drag due to lift at supersonic speeds of a delta wing-tail combination,** *Douglas Aircr. Co., Rep.* SM-13601, 14 pp., 1949.

Author obtains theoretical expressions for each of the contributions to the total induced drag of a delta wing-tail combination. Examples computed show that the tail contribution can be considerable. Maurice Holt, England

2317. **Graham, Martha E., Effect of linear symmetric twist on drag of rectangular wing in supersonic flow,** *Douglas Aircr. Co., Rep.* SM-13303, 15 pp., 1948.

This paper, making use of linearized supersonic flow theory developed in previous papers by Lagerstrom, shows that the drag due to linear twist in a rectangular wing depends on Mach speed, aspect ratio, and amount of twist, and is independent of wing attitude or lift. It is shown that a strip theory modified to allow for tips effects gives results which approximate the complete theory rather well for aspect ratios not below three. The results are presented in two graphs showing (a) drag at zero lift and no thickness, and (b) drag of a twisted wing of symmetric double-wedge section. The drag due to moderate amounts of twist (3°) is small (equivalent to increases of 2 or 3% of the percentage thickness ratio). M. G. Scherberg, USA

2318. **Smiley, R. F., Water-pressure distributions during landings of a prismatic model having an angle of dead rise of 22½° and beam-loading coefficients of 0.48 and 0.97,** *NACA TN* 2816, 37 pp., Nov. 1952.

Author presents instantaneous pressure measurements obtained at 43 points on a model float described in the title. In addition, the loads, motions, and piled-up water data are given for tests which were made at fixed trims up to 30° and at flight-path angles of 90° and between 0° and 26° with the horizontal. The model had a 40.6-in. beam at the step and was acted upon by a hydraulically actuated constant-lift device providing forces equal and opposite to the ballasted weights of 1177 and 2369 lb. Peak pressure coefficients are compared with a theoretical relationship of Pierson and Leshnover [*Inst. aero. Sci., Sherman Fairchild Fund Paper* no. FF-2] and with a previously derived semi-empirical relationship by the author [AMR **5**, Rev. 2134]. An improved semi-empirical relationship is suggested which gives good agreement with the experimental results. T. F. O'Brien, USA

2319. **Beane, Beverly, The effect of planform on the lift to drag ratio of wing-body combinations at supersonic speeds,** *Douglas Aircr. Co. Rep.* SM-14454, 39 pp., July 1952.

Report considers the effect of the upwash due to the body on the lift and lift-drag ratio of supersonic wing-body combinations. The calculations are based on an approximate linear theory and friction drag is neglected, but reviewer believes they provide a valid basis of assessing this effect. Author concludes that the effect of the body may not be neglected when selecting a wing planform for optimum L/D, since the increase due to interference may be as high as 25% for low values of the reduced aspect ratio $(M^2 - 1)^{1/2}AR$.

Lift-curve slope has been computed for two body cross-section shapes, circular and elliptical; and for three classes of wings, (1) rectangular, (2) delta, (3) triangular, with both sweptback and sweptforward trailing edges. Values of $dC_L/d\alpha$ of the wing-body combination may exceed the two-dimensional, even for values of the reduced aspect ratio as low as 2. B. Etkin, Canada

2320. **Foote, J. R., and Scherberg, M. G., Dynamics of the opening parachute,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 131–144, 1952. $6.

By postulating a model, authors set up the equations of continuity and motion of an opening parachute. The mass-balance equation includes semi-empirical terms to account for the porosity of the cloth (a function of dynamic pressure and, hence, altitude), and flexibility effects on the mouth opening; vent effects due to the vent in the crown of the canopy have been neglected. The drag term in the equation of motion is the sum of the usual viscous term and inertial drag terms as calculated by F. S. Weinig for an expanding sphere. An empirical variation is used to account for the change in drag coefficient with porosity coefficient. The equations are solved for exemplary cases to predict opening rates as well as the shock forces experienced during the opening process. Some experimental evidence is quoted in support of the predicted loads in indicating that the theory yields answers correct in order of magnitude. The variation of these parachute characteristics with altitude is discussed.

G. V. Bull, Canada

2321. **Smiley, R. F., A theoretical and experimental investigation of the effects of yaw on pressures, forces, and moments during seaplane landings and planing,** *NACA TN* 2817, 98 pp., Nov. 1952.

A theoretical investigation was made of the hydrodynamic forces and moments during yawed water landings and planing of seaplanes. For the case of the nonchine-immersed straight-sided wedge, the time histories of side force and rolling and yawing moments are expressed as families of generalized curves. Experimental measurements made in the Langley impact basin with a float of dead rise of 22.5° are presented. There is a reasonable agreement with the theoretical predictions.

G. V. R. Rao, USA

Aeroelasticity (Flutter, Divergence, etc.)

2322. **Lambourne, N. C., An experimental investigation on the flutter characteristics of a model flying wing,** *Aero. Res. Counc. Lond. Rep. Mem.* 2626, 24 pp., Apr. 1947, published 1952.

This report describes some preliminary experimental work that has been carried out in an attempt to gain information on the flexural-torsional flutter characteristics of flying-wing types of aircraft. Tests were made with two flexible tip-to-tip models: (A) Rectangular planform, (B) cranked and tapered planform.

The method of supporting the models in the wind tunnel allowed certain bodily freedoms to be present either singly or simultaneously, and measurements were made of critical speeds and frequencies, and in a few cases the flutter motion was analyzed by means of cinematograph records. The experimental results are in no way conclusive and cannot be directly applied to full-scale problems, but they do point to some of the difficulties in the treatment of the flutter of flying wings. Further, the difficulties encountered during the flutter tests themselves lead to suggested modifications in the technique of providing a model in a wind tunnel with the bodily freedoms appropriate to free-flight conditions. From author's summary

2323. **Dengler, M. A., and Goland, M., The calculations of spanwise loadings for oscillating airfoils by "lifting line" techniques,** *J. aero. Sci.* **19,** 11, 751–759, Nov. 1952.

Aim of paper is to derive a simplified method of determining loading of oscillating swept wings. Authors review existing steady and unsteady flow theories, emphasizing the physical

reasoning and assumptions. A typical horseshoe vorticity pattern is shown to be equivalent to a two-dimensional vorticity distribution together with a pattern consisting of two trailing vortexes and two spanwise semi-infinite vorticity distributions. Simple formulas are obtained for the downwash due to these distributions.

By considering surface loading, authors show that the Prandtl-Cicala lifting-line theory can be reproduced if the interaction of the bound vorticity at different spanwise stations is neglected. With this assumption, wake flows can be considered to start at any arbitrary chordwise point, and induction is relatively constant over the wing.

Authors next consider Weissinger steady-flow theory, showing that it allows for interaction of the bound vorticity at different spanwise stations, this being essential for swept wings. Weissinger theory is then extended to the oscillating airfoil, bound vorticity being replaced by a line vortex at the quarter-chord line, the wake starting at the quarter-chord point. As in steady-flow theory, boundary conditions are satisfied at the three-quarter chord line. By considering this theory as applied to a two-dimensional wing, it is shown that bound vorticity must be multiplied by an arbitrary factor.

The method is applied to an unswept wing and to a wing with 45° sweepback for various spanwise symmetrical modes of motion, and results for the unswept wing are compared with those from other methods, fair agreement being obtained. Sweepback reduces the inboard wing loading, as in steady flow.

Possible extensions suggested are to use (1) two discrete line vortexes instead of one [Holme, Stockholm *KTH-Aero. TN* 26]; (2) small span unswept horseshoe patterns [Diederich, AMR **4**, Rev. 3951]. Reviewer would like to see comparison with similar work based on lifting-surface theory [AMR **3**, Rev. 1120; *Aero. Res. Counc. Lond. Rep. Mem.* 2470].

A. W. Babister, Scotland

2324. Brower, W. B., and Lassen, R. H., Additional values of $C(k)$, *J. aero. Sci.* **20**, 2, 148–150, Feb. 1953.

Tables represent an important and valuable extension of the tables by Y. L. Luke and M. A. Dengler [AMR **5**, Rev. 221] on the Theodorsen circulation function $C(k)$ for real argument k. Tables record numerical values over the following range: $k = 1.0\ (0.02)\ 5.0\ (0.1)\ 10.0\ (0.5)\ 16.0$. The error is $\leq 3 \times 10^{-7}$. Using a three-point Lagrangian interpolation table, it is possible to interpolate for k given to six decimals with an estimated error $\leq 5 \times 10^{-6}$.

M. A. Dengler USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2166, 2345, 2385, 2387)

2325. Mallinson, D. H., and Lewis, W. G. E., Performance calculations for a double-compound turbo-jet engine of 12:1 design compressor pressure ratio, *Aero. Res. Counc. Lond. Rep. Mem.* 2645, 29 pp., Nov. 1947, published 1952.

Report describes a theoretical investigation using conventional component characteristics to discover that division of work between the low- and high-pressure compressors of a double-compound simple-jet gas turbine of 12:1 design pressure ratio which is likely to result in the most desirable equilibrium operation over the normal engine-speed range. Having decided in favor of a pressure ratio of 3:1 in the low-pressure compressor and 4:1 in the other, a study is then made using more realistic compressor characteristics to determine the probable performance of such an engine under all flight conditions when the design maximum temperature is 900 C (1173 K). The equilibrium running conditions of the engine are investigated with special reference to the problems introduced by the double-compound type of design.

From authors' summary

2326. Casci, C., Torsional loads on axial-flow compressor blades (in Italian), *Monogr. Lab. Aero. Politecn. Torino* no. 284, 6 pp., 1952.

Author calculated the pitching moments due to aerodynamic and centrifugal forces acting on the rotor blades of an experimental axial-flow compressor by numerical integration of the equations obtained in the usual way for twisted blades. The calculations were made to find whether rotor blades could be screwed into the hub without danger of unscrewing in operation. The author compares the calculated moments with test results obtained by measuring the unscrewing torque of a blade with various axial loads. The blade root is threaded into a blind hole with a Belleville spring in the bottom of the hole to provide locking tension.

D. Morelli, USA

2327. Maillet, E., Steps for the perfection of compressors and turbines (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 465–490, 1952.

Starting with their late evolution, author points out the differences between turbojet and turbopropeller units for wide power range, followed by the characteristic parameters of axial-, radial-, and mixed-flow compressors for aviation and land units. Comparing cascades of different profiles, solidity, stagger, and pitch, he establishes, for axial-flow units, the adaptability of particular types to particular duties, their limiting Mach number, effects of clearance between stationary and rotating walls and boundary layers in converging and diverging passages. Further research is suggested with novel instrumentation for three-dimensional flow and pressure-pulsation effect on adjoining blade rows. Smaller single-stage and larger two-stage radial-flow machines with increased pressure ratio are described and improvements shown with backward curved instead of 90° compressor vanes; also with a mixed-flow impeller in place of the axial inducer joining abruptly the radial impeller. The influence of the clearance between case and vanes on the volute or diffuser flow and the pressure pulsations caused by the passage of the rotating channels at the stationary vanes are illustrated and suggested as difficult but fertile fields for further investigations.

A. Hollander, USA

2328. Èpshteĭn, L. A., On the work of the ideal supercavitating propeller (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **9**, 19–26, 1951.

The term "supercavitation ship propeller" indicates the performance of ship propellers having the top camber of each blade completely covered by a cavitation cavern. The caverns fade away a certain distance aft of the rear edges of the vanes.

Author discusses papers by Bassin and Lavrent'ev and tries to estimate the influence of the afore-mentioned cavitation cavern on the flow characteristics of the ship propeller. This is done on the basis of simple stream theory. The analysis is based on the following assumptions: (1) The motion of the fluid in the jet is irrotational; (2) the cavitation caverns extend into the jet and reach far behind the vanes where they finally vanish; (3) the flow is nonviscous. On the basis of these assumptions, the upper limits of efficiency of a supercavitation propeller are deduced. Numerical values depend on the cavitation coefficient σ and the frequency of the propeller.

Remarks of reviewer: Same problem may also be studied by means of the airfoil theory and the theory of free jets. The

reader is also referred to paper by A. Betz: "Influence of cavitation on the efficiency of ship propellers," *Proc. 3rd inter. Congr. appl. Mech.* I, 411–416, Stockholm, 1930.

M. Strscheletzky, Germany

2329. **Rieke, K. L., Temperature and gas-analysis surveys in the combustion zone of a gas-fired gas-turbine combustor,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-97, 9 pp., 13 figs.

Detailed information on admission, mixing, and reacting of fuel and oxidant in gas-turbine combustors is important for achieving optimum design. Author reports traverse surveys of temperature and composition at two positions downstream from fuel nozzle in combustion chamber similar to that in a 2000-hp turbine.

Temperatures were measured with a radiant target pyrometer and a sonic-flow orifice probe, the latter proving more reliable for this application. The continuous gas-sampling procedure utilized an oxygen analyzer. Fuel-air ratio was computed from the analysis.

The sonic-flow orifice probe showed nearly symmetrical temperature distribution with a maximum value near the wall and a minimum in the curve at the center. Mixtures near the center were rich, those at the wall very lean. Maximum temperatures corresponded to slightly greater than stoichiometric ratio. Measured temperatures were lower than equilibrium temperature for laminar premixed flames. Author attributes difference to radiation loss from the luminous combustor flame.

Marjorie W. Evans, USA

2330. **Patterson, A. M., Factors affecting the performance of supersonic diffusers,** *Inst. Aerophys. Univ. Toronto Rep.* no. 23, 22 pp., 5 tables, 26 figs., Dec. 1952.

Report is concerned with improving the performance of diffusers without the expense and complications of a variable throat. Effects of diffuser length, throat area, throat length, and the application of suction are investigated experimentally. Author finds that a gain in pressure recovery of about 15% over a convergent-divergent diffuser of optimum length can be realized by extending the length of throat with a constant area and applying suction to start the diffuser. A. H. Sacks, USA

2331. **Medici, M., Experimental contribution to the study of the Kaplan turbine** (in Italian), *Ric. sci.* **22**, 9, 1699–1705, Sept. 1952.

Author presents the results of a series of tests aimed at determining how the efficiency of Kaplan turbines is affected by variations in the hub diameter to outer diameter ratio of the runner, in the number of blades, and in the rotation speed. While the root and tip length of the blade and the ratio of blade length to blade spacing have been kept constant in the experimental turbines, the ratio of hub diameter to outer diameter has been varied between the values 0.685 and 0.416, the number of blades between 8 and 4, and the rotation speed between 1600 and 1000 rpm.

The results are given in terms of efficiency plotted against specific speed. They show that highest efficiency is obtained, in the whole field of rotation speeds investigated, by increasing the ratio of hub diameter to outer diameter and the number of blades, as the specific speed decreases. P. L. Romita, Italy

2332. **Stanitz, J. D., and Ellis, G. O., Flow surfaces in rotating axial-flow passages,** *NACA TN* 2834, 31 pp., Nov. 1952.

The distortion of flow surfaces in rotating passages with potential absolute flow is calculated without taking into account the influence of spanwise blade-loading variations. The solution is obtained by superposition of rotational relative flow for zero through flow, and through flow in stationary passage. Results show relatively small distortions for cases corresponding to axial compressor bladings. Considerable distortions occur with blade passages which are long in meridional direction, such as mixed-flow impellers. E. Haenni, Switzerland

2333. **Ketchum, J. R., and Craig, R. T., Simulation of linearized dynamics of gas-turbine engines,** *NACA TN* 2826, 25 pp., Nov. 1952.

Through use of electronic analog computer in simulation of controlled aircraft-engine performance, one method of engine simulation has proved to be preferable from many considerations. Equations used in developing this method of simulating dynamics of gas-turbine engines are derived in general form from engine functional relations. This general simulation method can be utilized in consideration of any first-order linear system and is designed for use in conjunction with control components for small perturbation or stability studies of controlled system operation.

Simulation of response of a turbojet engine to a step change in an independent variable is made, and comparison of the experimental and simulated results indicates validity of simulation method presented. Limitations on use of altitude and flight-speed generalization factors in determining the coefficients necessary for the simulation of engine dynamics are discussed.

From authors' summary by J. G. Slotboom, Holland

2334. **Mizisin, J., and Michel, D. J., Effect of changing passage configuration on internal-flow characteristics of a 48-inch centrifugal compressor. II. Change in hub shape,** *NACA TN* 2835, 35 pp., Nov. 1952.

This paper represents a continuation of work done on a particular centrifugal compressor [AMR **6**, Rev. 246]. The shape of the hub is changed to decrease the deceleration flow rate of the air. However, this results in increased clearance losses because of the greater ratio of clearance to blade height, and the efficiency at the impeller exit is about the same. Large losses occur at the driving-face inlet at negative angles of attack and in the region of the large decelerations along the trailing-face flow surfaces. However, this condition was also found in the original and modified-blade impellers. A. H. Church, USA

Flow and Flight Test Techniques

2335. **Lukasiewicz, J., Design and calibration tests of a 5.5 in. square supersonic wind tunnel,** *Aero. Res. Counc. Lond. Rep. Mem.* 2745, 36 pp., Feb. 1950, published 1952.

The main design features of the wind tunnel are described and results are given of the investigations carried out to determine (1) the minimum pressure ratio required to operate the wind tunnel at Mach numbers up to 3.5, and (2) the uniformity of the velocity distribution in the working section at Mach numbers of 1.57, 1.88, 2.48, 2.85, 3.25, and 3.5.

It was found that the tunnel pressure recovery can be appreciably increased by means of a contraction ("second throat") located between the working section and subsonic diffuser.

All nozzles tested were designed with short throats and expansion profiles with the maximum angles of expansion for the given exit Mach number. The axial variation of Mach number over selected intervals of working section (not smaller than 5 in.) was found to be of the order of $\pm 1.0\%$.

It was found that condensation in the wind-tunnel nozzle (run with atmospheric air) has a detrimental effect on the velocity

distribution in the working section, particularly at small Mach numbers. From author's summary

2336. Farbar, L., The Venturi as a meter for gas-solids mixtures, ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-31, 8 pp., 10 figs.

Paper describes experiments where Venturi tubes with throat diameters of 0.500 and 0.375 in. were used for metering flow of gas-solids mixtures containing particles of size 10 to 220 micron. Constant gas flow was essentially incompressible. It is shown that from the energy equation a linear relationship between Venturi differential and solids flow rate can be predicted. This was substantiated by the experiments. Constants could not be determined readily from theory, but use of Venturi is not restricted, as meter may be calibrated in place.

The pressure recovery at the diffuser end of the Venturi tube decreased rapidly with increasing solids rate. Author mentions possible use of Venturi as solids meter in industry. Even in cases where calibration cannot be made, instantaneous changes in solids flow rate can be observed. E. Krahn, England

2337. Blackburn, J. F., Contribution to hydraulic control, ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-43, 5 pp., 4 figs.

Several devices based on the hydraulic analog of the Wheatstone bridge are discussed. These include bridges and derived configurations for which flow is proportional to pressure but independent of the viscosity of the liquid used, fluid sources with linear output resistances, and a bridge for the direct measurement of hydraulic conductance.

From author's summary by J. S. Marcus, USA

2338. Dimeff, J., Hallett, R. K., Jr., and Hansen, C. F., X-ray instrumentation for density measurements in a supersonic flow field, *NACA TN* 2845, 39 pp., Dec. 1952.

An x-ray beam is essentially undeviated while traversing a short path in air. At wave lengths of approximately 6 Ångstrom, sufficient absorption occurs in air to allow satisfactory measurement of densities at a total density as low as approximately 2×10^{-5} g/cm^3. An instrument based on this principle is described. The advantages of this type of instrument accrue from the fact that, refractive effects being negligible, data are related to path elements geometrically fixed with respect to the tunnel.

The measurement is accomplished by comparing the intensity of two beams from the same x-ray source. Both beams have the same path length and pass through the same number of windows. Thus, the only difference in the two paths is that due to the absorption within the wind tunnel. From authors' summary

2339. Stewart, J. D., A preliminary investigation of the effects of condensation and slip flow in the UTIA 5″ × 5″ supersonic wind tunnel, *Inst. Aerophys. Univ. Toronto, Rep.* no. 22, 21 pp., 23 figs., Oct. 1952.

Tests were conducted in a 5- × 5-in. blow-down tunnel in a stagnation temperature range from 20 C to 400 C. A wedge nozzle was used producing a minimum Mach number of 3. Test setup is described, and pictures are included of main tunnel components and probes and models. Some general remarks are made on the problems connected with the test technique in hypersonic wind tunnels, and a brief theoretical survey is given on tunnel-design data, condensation effects, and slip flow.

Primary purpose of tests was to determine whether condensation of the air occurred. Light-scattering tests and pressure measurements do not indicate any air-condensation effects up to the maximum obtainable Mach number of 6.5. Flow separation in the nozzle excluded higher Mach numbers. Test results seem to indicate that slip-flow conditions begin to form at approximately M = 4.0. This is concluded from two observations: First, the temperature-recovery factor changes at this Mach number opposite to the effect which would be expected because of boundary-layer transition in this range. Second, the Mach numbers as determined by static pressure measurements decrease with increasing stagnation temperature. Additional studies, as schlieren pictures and wake surveys, did not give positive checks for the results obtained.

More results and a detailed analysis will be necessary to separate the influences superimposed in the tests.

H. J. Ramm, USA

2340. Naylor, V. D., An experiment on nozzle flow, *Aircr. Engng.* **24,** 285, 344–347, Nov. 1952.

Author shows by experiments on a nest of conical nozzles of apex angle 20° 36′ that the inlet and outlet pressure-volume relationship is similar to the ideal-gas adiabatic law for pressure ratios from 1 to 3, in which range the limiting exit velocity is attained, except that the exponent corresponding to the specific heat ratio has the value 1.345. The expression for sonic velocity obtained in a previous paper by the same author is also confirmed.

R. C. Makino, USA

2341. Sinclair, A. R., and Robins, A. W., A method for the determination of the time lag in pressure measuring systems incorporating capillaries, *NACA TN* 2793, 35 pp., Sept. 1952.

Authors consider the problem of time lag in cases where the tubing connecting the orifice to the pressure-measuring device is filled with compressible fluid and the flow in the tubing is laminar. The equations show, of course, that infinite time is required to reach equilibrium. However, the time lag for any preselected error in reading may be evaluated.

In many applications the total length of tubing in series is fixed, and the diameter of some of the tubing is determined by space limitations. An equation is developed for determining the diameter of the remainder of the tubing which will result in minimum time lag by balancing total system volume against capillary resistance.

The equations apply to the usual arrangement, in which most of the capillary resistance occurs near the pressure orifice and most of the volume is near the pressure measuring device. For other arrangements, the equations will give pessimistic values.

Experimental data are presented which show reasonably good agreement with the theory. J. Levy, USA

Thermodynamics

(See also Revs. 2293, 2306, 2329)

2342. Egerváry, J., and Turán, P., On some questions of the kinetic theory of gases (in Hungarian), *Magyar Tud. Akad. Mat. Fiz. Oszt. Közleményei* **1,** 303–314, 1951.

2343. Milsum, J. H., Electrically heated aircraft windscreens, *Nat. aero. Establ. Canad.* LR-43, 16 pp., Dec. 1952.

Electrically conducting films were originally developed to protect surfaces against the build-up of electrostatic charges, but another important application followed in effecting the heating of transparent laminated panels. It had been shown that laminated safety glass had maximum shock impact strength at about 90 F and that this strength fell off at higher or lower temperatures. The heating of aircraft windscreens to maintain this temperature was, therefore, desirable for this reason alone.

However, in addition, this system offered a convenient method of thermal anti-icing, overcoming difficulties associated with existing methods. From author's summary

2344. **Münster, A., Statistical mechanics of phase transitions II. Transitions of higher order** (in German), *Z. Naturforsch.* **7a**, 9, 613–619, Sept. 1952.

The occurrence of thermodynamical singularities is correlated to the mean powers of deviation of dynamical variables such as the energy. Introducing reduced distribution functions which are appropriate to a representative group of a small number of molecules, their relation to the above mean powers is considered and discussed. Paper does not reach beyond any essential result as obtained by previous authors. R. Eisenschitz, England

2345. **Harper, D. B., and Rohsenow, W. M., Effect of rotary regenerator performance on gas-turbine plant performance,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-149, 7 pp., 12 figs.

Paper analyzes the efficiency of a simple gas-turbine plant using a rotary-type regenerator. The effects of leakage, pressure drop, and regenerator effectiveness on plant performance are shown in the form of curves illustrating the importance of leakage. If regenerator effectiveness is based on temperature only, leakage does not influence generator effectiveness seriously. However, the leakage loss has a much greater effect on plant efficiency and work output than either pressure loss or regenerator effectiveness. An analysis of characteristic regenerator dimensions is shown graphically, indicating the effects on plant efficiency and optimum conditions. The analysis shows the design conditions and performance which the rotary-type regenerator must fulfill for gas-turbine applications. H. E. Sheets, USA

2346. **Mazur, P., On the states of minimum entropy for continuous systems** (in French), *Acad. roy. Belgique. Bull. Cl. Sci.* (5) **38**, 182–196, 1952.

The author's purpose is to generalize to the case of continuous media a theorem of Prigogine ["Étude thermodynamique des phénomènes irréversibles," Desoer, Liège, 1947] to the effect that steady nonequilibrium states are characterized by a minimum of entropy production. He states that the paradoxical results of Haase [AMR **5**, Rev. 891] in this connection are due to an incorrect formulation of the principle. The author's method is to consider examples. First, in the case of simple heat conduction the rate of entropy production is proportional to the volume integral of [grad $(1/T)$]^2. Minimization leads to Fourier's equation for the steady case. The author shows also that when the temperature is constant on the boundary, in a nonsteady state the rate of entropy production decreases steadily with the time. From this he concludes that the states of minimum entropy production are stable. The author's second example concerns electric currents; the third, thermal diffusion and chemical reactions.
C. Truesdell, USA

2347. **Grad, H., Statistical mechanics, thermodynamics, and fluid dynamics of systems with an arbitrary number of integrals,** *Comm. pure appl. Math.* **5**, 4, 455–494, Nov. 1952.

The canonical distribution is generalized such as to account for the dependence of the probability upon any constants of motion (apart from the energy). Thermodynamics and irreversible thermodynamics are generalized correspondingly. Paper is largely a survey of matters known before; original contributions are made to the methods of deduction rather than to the results. In a section on continuum mechanics, author emphasizes the fact that, in general, the stress tensor is not necessarily symmetric, but gives reasons to show that deviation from symmetry is likely to be negligible. Reviewer considers the paper to be well written but misses any clear statement of the underlying physical hypotheses as distinct from their mathematical evaluation.
R. Eisenschitz, England

2348. **Grubenmann, M., *I*, x-diagrams for wet air and their use for heating, cooling, humidifying, dehumidifying of air in water-return cooling and in drying [*I*, x-Diagramme feuchter Luft und ihr Gebrauch bei der Erwärmung, Abkühlung, Befeuchtung, Entfeuchtung von Luft bei Wasserrückkühlung und beim Trocknen] 3rd compl. ed.,** Berlin, Springer-Verlag, 1952, 46 pp. DM 13.50.

The third edition of this booklet on the enthalpy-composition diagrams for moist air differs from the preceding edition by presenting diagrams in place of tables and by use of rectangular coordinate charts in place of oblique-angle coordinate charts.

The book presents some 40 pages of examples, sketches, and simplified analyses illustrating the applications of three enthalpy-composition diagrams to a large group of processes involving moist air. These diagrams are based on the data of R. Mollier, published in 1923, and the perfect-gas laws for air and water vapor. J. Kaye, USA

2349. **Benton, A., and Inatomi, T. H., The thermodynamic properties of sodium vapor,** *J. chem. Phys.* **20**, 12, 1946–1948, Dec. 1952.

The free energy, enthalpy, entropy, and specific heat for both monatomic and diatomic sodium vapor have been calculated from spectroscopic data by the well-known methods of statistical mechanics. Also, the equilibrium constant K_p for the gaseous reaction $Na + Na = Na_2$, as well as the entropies and enthalpies for the equilibrium mixture of these two species were obtained. These calculations were made for the vapors as ideal gases at a pressure of 1 atm, and for the temperature range 100 K to 2600 K. The results are presented in tables.
From authors' summary

Heat and Mass Transfer

(See also Revs. 2310, 2348)

2350. **Kamínin, L. I., On the convergence of a finite-difference process for the heat conduction equation** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **85**, 701–703, 1952.

2351. **Madejski, J., Solution of Laplace's equation under certain boundary conditions and its application to the theory of heat conductibility in homogeneous isotropic solids** (in Polish), *Arch. mech. stos.* **3**, 2, 147–156, 1951.

Author calculates heat expenditure for fixed heat flow for a pipe with a square section ($b - a$ = thickness of wall). The boundary problem, in which the temperature distribution function satisfies the plane Laplace equation, is solved by the author with the help of a "sewing-up" method based on the procedure adopted by N. H. Arutyunyan [*Prikl. Mat. Mekh.* **13**, 1, 1950]. For the determination of constants a regular infinite system of linear equations is obtained and is solved by the method of successive approximations. In the formula for the expenditure of conducted heat $Q = \lambda\vartheta \cdot F(\delta)$ (where ϑ is the temperature difference, λ the conductivity factor, $F(\delta)$ the factor accounting for cross-sectional shape, and $\delta = (b - a)$), $F(\delta)$ can be replaced by $8/\delta$ for $\delta \leq 1$. However, $F(\delta)$ cannot be replaced by $8/\delta^*$, where $\delta^* = (b - a)/b$. J. Nowiński, Poland

2352. Halatnikov, I. M., Heat exchange between a solid body and Helium II (in Russian), *Zh. eksp. teor. Fiz.* **22,** 687–704, 1952.

2353. Chandrasekhar, S., The thermal instability of a fluid sphere heated within, *Phil. Mag.* (7) **43,** 1317–1329, Dec. 1952.

The problem of the thermal instability of a sphere in which heat is being generated is of interest in geophysics and astrophysics. The author considers this problem for uniform heat generation in a fluid in equilibrium under its own gravitational field. Linearized disturbance equations are set up, assuming laminar incompressible flow. By using the radial component of the velocity as the dependent variable, the eigenvalue problem assumes a convenient form. A variational procedure is developed and numerical results obtained for the case of a rigid and free boundary. A further paper is promised in which some mathematical details will be justified and the case of a spherical shell will be treated.

Reviewer's note: The paper seems relevant to the problem of cell division as discussed by Rashevsky, "Mathematical biophysics," University of Chicago Press, 1948.

W. Squire, USA

2354. Wassermann, G. D., Heat conduction in solids as an eigenvalue problem, *Quart. J. Mech. appl. Math.* **5,** part 4, 466–471, Dec. 1952.

Author presents a formalized method for obtaining boundary-value solutions of the transient, constant-property, temperature distribution equation $\nabla_a{}^2 t = (1/\alpha)(\partial t/\partial \theta)$, in which direct application of Laplace transforms is avoided by first establishing a general transform between the time-dependent Green function of the heat-conduction problem and the time-independent Green function of an associated elliptic differential equation. The method encompasses one-dimensional solutions in both finite and infinite domains, initial-value solutions, uniform sources or sinks, and nonstationary sources. Example solutions in terms of normalized eigenfunctions and eigenvalues are compared with equivalent solutions by Carslaw and Jaeger.

P. J. Schneider, USA

2355. Paterson, S., On certain types of solution of the equation of heat conduction, *Proc. Glasgow math. Assoc.* **1,** 48–52, 1952.

For each of the partial differential equations $f_t = f_{rr}$, $f_t = f_{rr} + f_r/r$, and $f_t = f_{rr} + 2f_r/r$, particular solutions are found under the assumption $f = f(\zeta)$ where $\zeta = \phi(r) \cdot \psi(t)$.

Courtesy of Mathematical Reviews F. G. Dressel, USA

2356. Giannone, A., On the measurement of thermal diffusivity of refractories (in Italian), *Termotecnica* **6,** 11, 489–492, Nov. 1952.

The author presumes, on the one hand, that it is possible to vary the temperature of the heated face of a large flat sheet as desired and, on the other hand, that a certain initial temperature distribution can be obtained; the appropriate solution of the Fourier equations is then found which, if temperatures at certain points of the sheet are measured, enables the thermal diffusivity of the material to be determined. He finds another simpler and more tractable formula than the previous one by Schmidt's graphical method.

In the first case, the desired laws of temperature variation and initial temperature distribution seem difficult to obtain in practice. In the second case, the difficulty is to measure local temperatures; if thermocouples are used, for example, the temperature distribution is disturbed and the point at which the measurements are made cannot be exactly defined. The resulting errors may be appreciable. Reviewer believes that certain determinations of the thermal diffusivity have already been made by temperature measurements at different stages of the heating of simply shaped test specimens; see Max Jakob, "Heat transfer," p. 313, where applications of the unsteady-state equations are given.

S. Casacci, France

2357. Ostrach, S., Laminar natural-convection flow and heat transfer of fluids with and without heat sources in channels with constant wall temperatures, *NACA TN* 2863, 55 pp., Dec. 1952.

General problem is formulated in terms of three dimensionless parameters: Prandtl and Grashof numbers, and the hitherto unused product $\beta f d/c_p$. β is coefficient of the volumetric expansion at constant pressure, f is body force per unit mass, d is a characteristic length, and c_p is specific heat at constant pressure. Attention is directed toward instances in which this product is not numerically negligible, especially toward an assumed fully developed flow between long walls parallel to the body force. Results of numerical calculations for dimensionless velocity and temperature distributions and for Nusselt number are presented graphically; these clearly show effects of wall-temperature ratio, heat sources, and frictional heating and compression work. Results are not compared with experiment since virtually no pertinent data exist.

F. T. Rogers, Jr., USA

2358. Crocco, L., An approximate theory of porous, sweat, or film cooling with reactive fluids, *J. Amer. Rocket Soc.* **22,** 6, 331–338, Nov.-Dec. 1952.

Rannie's approximate theory of porous cooling for inert coolants is here extended to the case in which the coolant itself is reactive (for instance, the coolant is one of the propellants). The primary feature of this analysis is the assumption that the flow of the main body of gas may be divided into two regions—a central turbulent core which is not affected by the cooling process, and a region adjacent to the wall where all the effects of the cooling process are confined and which can be treated as the conventional boundary layer. Other simplifying assumptions involve neglecting axial gradients and the effect of coolant velocity on the hydrodynamic conditions of the boundary layer; the liquid film is assumed to be stable on the wall. When the coolant is reactive, further assumptions are made: The combustion gases diffuse as a whole; reaction times are short with respect to other times involved; in the laminar layer the diffusion rate of oxygen-carrying combustion gases is proportional to their total molecular concentration gradient; and in the turbulent region the Reynolds analogy is extended to mass transport. With these assumptions a general solution is obtained and reduced to forms specifically applicable to the cases of porous cooling, film cooling, and sweat cooling. A numerical example is presented for the case of sweat cooling in which the coolant is the fuel itself.

W. M. Rohsenow, USA

2359. Köhler, H., On evaporation from snow surfaces, *Arkiv Geofys.* **1,** 2/4, 159–185, 1951.

Following Prandtl, von Kármán, and Sutton, a relation for the eddy diffusion coefficient as a function of height above the ground has been used to obtain (1) an expression for the rate of evaporation from a surface for an assumed water-vapor distribution near the ground, which is related to the wind velocity; (2) an expression for the evaporation in the direction of the wind per cm^2 per sec in the distance from the border of the evaporating compound.

Author applies his theoretical relations to empirical studies of evaporation from a snow surface, carried out at Haldde Observatory, Norway. Considering the numerous possible errors in the observations discussed by the author, good correlation with

expression (1) for the rate of evaporation of snow is obtained, thereby showing that the assumed functional form for the water-vapor distribution near the ground was reasonable. Measurements for evaporation rate, in the direction of the wind velocity, showed considerable scatter. Furthermore, the theoretical curve (2) could be made to coincide, approximately, with the mean empirical curve, only by adjusting the value of von Kármán's constant from 0.4 to 0.73. S. S. Penner, USA

Acoustics

(See also Revs. 2170, 2242)

2360. **Doak, P. E., The reflexion of a spherical acoustic pulse by an absorbent infinite plane and related problems,** *Proc. roy. Soc. Lond.* (*A*) **215,** 1121, 233–254, Nov. 1952.

A formal integral solution to the problem is obtained by extending a procedure due to Weyl [*Ann. Phys.* **60,** p. 481, 1919], i.e., the Laplace transforms with respect to time of the incident and reflected waves are represented as integral superpositions of plane waves traveling in complex directions. It is assumed that each plane wave satisfies the impedance boundary condition on the absorbent plane. A simple exact representation is derived for the case of a constant impedance independent of frequency (i.e., purely resistive). This case is considered in detail and compared with reflection from an interface between two homogeneous isotropic bossless media; the range of validity of assuming that the impedance is independent of angle of incidence is discussed. In addition, approximate evaluations of the integral solution are presented for the following impedances: resistance and mass; resistance and stiffness; resistance, mass, and stiffness. The results are compared with those obtained for incident plane waves. The material has applications to practical problems of room acoustics and to the reflection of blast waves.

V. Twersky, USA

2361. **Kneser, H. O., General theory of sound absorption in gases and liquids** (in German), *Atti Conv. Internaz. Ultracust.* 1950; 231–235, 1951.

Paper develops formalism by which absorption due to various relaxing adiabatic mechanisms in gases and fluids can be calculated by assignment of different values to various parameters in a single equation.

Under assumptions of generalized equation of state and monomolecular adiabatic reaction between a species and its "activated" form, the following equation is obtained

$$M_0 = \frac{2\pi^2}{c}\left(\frac{C_i}{C_a}\right)\frac{1}{\left(1 + Z\alpha T\,\frac{R}{C_a}\right)}\left(\gamma - 1 - \frac{\alpha}{\beta_0}\,\frac{V}{R}\,\frac{y}{x}\right)\tau$$

(M_0 is low-frequency amplitude absorption coefficient divided by frequency squared; c velocity of sound; C_i and C_a inner and outer heat capacities; $Z = pV/RT$; $\gamma = C_p/C_v$, where $C_v = C_i + C_a$; α coefficient of expansion (volume); β_0 low-frequency compressibility; y fractional change of molar volume ($= v/V$); $x = (Q + pv)/RT$ where Q is activation energy/mole; τ relaxation time.)

Assignment of proper values to parameters Z, y, x lead to specialized formulas for cases of liquid and gaseous heat-capacity relaxation as well as relaxation due to dissociation. Modification of analysis leading to primary equation yields formula for absorption due to liquid structural relaxation.

Reviewer believes approach to be a convenient and elegant one, although some errors are present. P. Tamarkin, USA

2362. **Hall, L. H., Attenuation of sound resulting from ionic relaxation,** *J. acoust. Soc. Amer.* **24,** 6, 704–708, Nov. 1952.

Effect of the long-range ion configuration on the relaxation peak in the sound absorption spectrum of strong electrolytes. Mathematical approach is similar to that employed by M. Leontovich [*Zh. eksp. teor. Fiz. SSSR* **8,** 1, 40–51, Jan. 1938], using the standpoint of the Debye-Hückel theory of strong electrolytes. Calculation is made of relaxation frequency and wave-length absorption coefficient for $MgSO_4$ solutions of 0.001 and 0.01 molality. Conclusion: Absorption reported to date for aqueous solutions of $MgSO_4$ (and other divalent sulfates) occurs at lower frequencies than here calculated and is not appreciably due to ionic relaxation but more likely to ion association or hydration processes. R. Heller, USA

✎2363. **Richardson, E. G., Ultrasonic physics,** Amsterdam, London, Houston, New York; Elsevier Publ. Co., 1952, x + 283 pp. $5.

During the past few years a number of books on ultrasonics have appeared, varying all the way from Bergmann's 5th edition of his monumental work "Der Ultraschall" to Vigoureux's small volume on ultrasonics. Since the field is becoming so large, it is a pleasure to read a book which discusses thoroughly one phase of ultrasonics, namely, methods of measuring the propagation properties of liquids and solids and some of the results that have been obtained in these fields. Prof. Richardson states that one of the main themes of "Ultrasonic physics" is the ultrasonic interferometer as a precision tool in the physics laboratory. He gives a thorough discussion of the sources of error in the interferometer and the reliability of the instrument. He also touches briefly on other methods, such as the pulse method, the optical methods for delineating a sound beam, and the low-frequency resonance methods.

After a thorough discussion of measurement methods, author discusses absorption and relaxation effects in gases and mixtures such as moist air, and the effects of pressure and temperature on such measurements. An omission in this field is that no mention is made of recent work on sound propagation in gases at low pressures. In the liquid field, absorption and velocity dispersion in pure liquids, mixtures, and solutions are well discussed. Enough theory is given to allow the student an insight into these processes. More recent results on shear waves in liquids of the viscoelastic type and the propagation of first and second sound in liquid helium are also discussed. In solids, propagation through plates and rods, dispersion of velocity in rods, relaxation in polymer materials, and scattering and diffusion of sound waves in materials with a grain structure are discussed. For a book of a small size (283 pages), the author has succeeded in touching on many phases of ultrasonics often overlooked. Thus the reader will find an account of ultrasonics of disperse systems such as aerosols, suspensions, bubbly mixtures, etc.

For a student with a good background in mechanics and electronics, this book is a very good introduction to the physics of ultrasonics. The book is illustrated by a large number of diagrams and graphs. The volume can be heartily recommended to workers in ultrasonics. W. P. Mason, USA

Ballistics, Detonics (Explosions)

2364. **Garnier, M., Remarkable points on a trajectory** (in French), *Mém. Artill. fr.* **26,** 3, 625–684, 1952.

The chapters reviewed here hold for trajectories vertically upward. [For chaps. I–VI, see AMR **4,** Rev. 4009; **5,** Revs. 275, 1896, 2195.] Here the independent variable is the velocity. Chap. VII contains forms for calculating the elements such as

time and height (method G.H.M.) and for computing the derivatives of these and other elements. In chap. VIII, the following remarkable points are found: The point of discontinuity (Mach number 1), the extremum and the point of inflection of the Mach number, the extremum and the point of inflection for $\rho = w/g$ (w deceleration by the air resistance, g acceleration of gravity), and the points where the time or the height has a given value.

H. Schardin, Germany

2365. Raynor, S., Calibration of pressure gages for work in ballistics, *J. appl. Mech.* **19,** 4, 517–520, Dec. 1952.

For ballistics work where pressures of several thousand psi are encountered, it is essential that the gages used to measure transient pressures be checked against a standard gage of known behavior. Such a standard gage and the method of calibrating it are described. From author's summary

2366. Taylor, J., Detonation in condensed explosives, New York, Oxford Univ. Press; Oxford, at the Clarendon Press, 1952, xi + 196 pp., 10 plates. $5.

Book deals with mechanism of detonation of commercial blasting explosives, principal attention being given to the stable steady state of detonation rather than to details of initiation. Proceeding from observation that steady state of detonation exists with sufficient chemical energy liberated to maintain progress of detonation wave, hydrodynamic theory is used to calculate velocity of detonation wave, detonation pressure, temperature, etc.

Calculation of heat of explosion is based on a knowledge of the products of explosion in the final state and heats of formation of reactants and products. Explosives yielding only gaseous products and also those having a "condensed," i.e., nongaseous phase, are analyzed. Calculations made for steady plane wave are compared with experimental data. Many explosives exhibit either a high or low detonation velocity; conditions leading to each regime are discussed. Influence of finite diameter of explosive on wave velocity is discussed; experimental data are exhibited to show reduction in velocity with side losses. Structure of the reaction zone and mechanism by which reaction is initiated in each new layer of material are discussed.

This highly readable book may profitably be read simultaneously with Bowden and Yoffe "Initiation and growth of explosions in liquids and solids" (Cambridge, 1952), the two books dealing with complementary phases of theory of explosives.

H. K. Weiss, USA

Soil Mechanics, Seepage

2367. Barber, E. S., and Sawyer, C. L., Highway subdrainage, Highway Res. Bd. Proc. 31st ann. Meet., 643–666, 1952. $7.50.

This report does not attempt to establish design criteria; it presents methods and data on permeability and drainability of soil and indicates their application to highway subdrainage.

From author's summary by J. C. Geyer, USA

2368. Misener, A. D., An absolute method of determining thermal conductivity and diffusivity of soils, Frost action in soils, Symposium, Nat. Res. Counc. Highway Res. Bd., *Spec. Rep.* no. 2, 51–57, 1952. $3.75.

Author gives a practical method of determining thermal constants, conductivity K, and diffusivity α, of poor conductors such as soil. The method can be applied rapidly since it is not necessary to wait until steady heat flow develops. The accuracy is about 3%, and, by a slightly more complicated method of calculation, this error can be further reduced. Spherical and cylindrical heaters are discussed, together with their application. On the basis of measured quantity of heat-energy output of the source and temperature rise at different times and in one point, it is possible, with the known heat-conduction equation and by use of some graphs, to obtain constants K and α for the soil examined.

D. Krsmanović, Yugoslavia

2369. Thomson, A., and Bremner, P. C., Permafrost drilling and soil-temperature measurements at Resolute, Cornwallis Island, Canada, *Nature* **170,** 4330, 705–706, Oct. 1952.

Micromeritics

(See also Rev. 2336)

2370. Carstens, M. R., Accelerated motion of a spherical particle, *Trans. Amer. geophys. Un.* **33,** 5, 713–721, Oct. 1952.

The motion of an oscillating sphere suspended in a fluid between two springs has been studied experimentally and theoretically. These results are applied to the diffusion of particles in an oscillating fluid. H. C. Brinkman, Indonesia

Geophysics, Meteorology, Oceanography

(See also Revs. 2178, 2179, 2261)

2371. Monin, A. S., Variation of pressure in a barotropic atmosphere (in Russian), *Izv. Akad. Nauk SSSR Ser. Geofiz.* **1952,** no. 4, 76–85, 1952.

The atmospheric model determined by the equations of frictionless inviscid motion, the hydrostatic equation, the equation of continuity, and the polytropic equation of state is investigated, using the method of dimensionless parameters. The vertical component of motion is shown to be directly proportional to the horizontal divergence and to the height; the direction of vertical motion is determined by the horizontal divergence and the vertical lapse rate of temperature, upward for convergence in an adiabatic atmosphere. Local pressure tendency can be expressed in terms of the local variation of vertical motion with height. Potential vorticity is shown to be conservative. Finally, the method of Kibel' [*Izv. Akad. Nauk SSSR Ser. Geofiz.* **1940,** no. 5] is applied to obtain a first approximation to the pressure tendency in the base pressure field in terms of the field itself and its derivatives.

Courtesy of Mathematical Reviews W. D. Duthie, USA

2372. Spar, J., Thermal tides in the atmosphere, *Trans. Amer. geophys. Un.* **33,** 6, 810–816, Dec. 1952.

Atmospheric pressure variations produced by the diurnal heating cycle are studied theoretically by extension of a technique of Margules [*S.B. Akad. Wiss. Wien, Math.-natur. Kl.* **99,** 204, 1890]. Margules' two-dimensional analysis is given a quasi-three-dimensional character by vertical integration. Method involves treating variables in the hydrodynamic equations of motion as sums of mean values and perturbations. Integration of the equations with respect to height and substitution of the gas equation of state gives an equation relating the local rate-of-pressure change at a given level to the heating rate at the same level. Equation shows that the atmosphere tends to be resonant to a thermal forcing with 12-hr period, so that even a small second-harmonic component in the daily heating cycle will produce a 12-hr pressure cycle which is of the same order of magnitude as the 24-hr cycle. The 12-hr cycle is calculated to be the dominant one in low latitudes, in accordance with observation. Paper establishes suffi-

ciency of thermal cause of observed diurnal pressure oscillations but not necessity, so that possibility of gravitational solar atmospheric tide is not eliminated. E. W. Barrett, USA

2373. **Isimaru, Y., Fundamental vorticity equation and jet stream mechanism. Mechanism of the earth's atmosphere,** *Geophys. Mag., Tokyo* **24,** 1, 41–80, Aug. 1952.

This fourth paper in author's series on this general subject treats chiefly the maintenance of zonal motion in rotating atmospheric shell by diffusion (eddy transfer) of temperature and absolute vorticity. The general highly mathematical theory developed is applied to meridional transport in upper troposphere for simplified conditions. Separate and combined contributions of thermal and vorticity transfers to zonal air currents with continuous meridional vorticity distribution are evaluated, tabulated, and graphed. For vorticity transfer alone, the computed latitude of westerly jet stream agrees well with observed winter profiles; for combined transfer, with summer profiles of zonal wind. Rigorous solution is also given for generation of vorticity by viscosity, use being made of surface zonal, solid spherical, and cylindrical harmonics (Bessel functions). Formulation of subsidiary problems and methods are difficult to follow because of unconventional terminology. Form of diffusion equation used by author is open to criticism since partial instead of total derivative is written on left-hand side, rendering author's interpretation of equation $\nabla^2 T = 0$ dubious. F. A. Berson, Australia

2374. **Kierstead, H. A., Bottom pressure fluctuations due to standing waves in a deep, two-layer ocean,** *Trans. Amer. geophys. Un.* **33,** 3, 390–396, June 1952.

The pressure fluctuation in a deep ocean, due to short-period surface waves, is calculated by means of a simple physical model. It is shown, as was pointed out earlier by Longuet-Higgins, that the pressure under a standing wave varies at twice the frequency of the wave and with an amplitude proportional to the square of the wave amplitude and inversely proportional to the wave length, but that the pressure under a progressive wave is constant.

A similar calculation of the pressure fluctuation under a standing internal wave gives similar results, but the amplitude is diminished by the factor $(\Delta\rho/\rho)$.

Numerical calculations, using typical wave amplitudes, show that pressure fluctuations of about 30 millibars may occasionally be expected under six-second surface waves, but that internal waves, because of their large wave lengths, will have little effect on the pressure in the deep ocean.

From author's summary by R. O. Reid, USA

2375. **Fjeldstad, J. E., Observations of internal tidal waves,** "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 39–45, Nov. 1952. $1.75.

In order to explain the variation of the current, salinity, and temperature of sea water as a function of depth and time, author published a theoretical investigation of internal waves in a medium of continuously varying density (1933). Present paper reports two series of observations of internal tidal waves taken in Herdlafjord, near Bergen, Norway, which tend to confirm the previously published theoretical treatment. The notation of this paper is not fully explained, but it can be easily derived from the slightly different notation of the earlier paper. Incidentally, the title of the theoretical paper is given incorrectly. It should be "Internal Wellen" (internal waves) (German text). The source is correct.

Other data confirming the theoretical treatment have been published in Sverdrup, H. U., Johnson, M. W., and Fleming, R. H., "The oceans, their physics, chemistry, and general biology," New York, Prentice-Hall, Inc., 1942 p. 589–602, and Ufford, C. W., "Internal waves in the ocean," "The theory of internal waves," and "Internal waves measured at Three Stations," *Trans. Amer. geophys. Un.* **28,** 1, 79–101, 1947.

D. L. Harris, USA

2376. **Smolyakov, P. T., On the reduction of the equations of motion in the atmosphere to ones integrable by quadratures** (in Russian), *Izv. Kazan. Filial. Akad. Nauk SSSR Ser. Fiz.-Mat. Tekh. Nauk* **1,** 75–78, 1948.

2377. **Charney, J. G., On the scale of atmospheric motions,** *Geofys. Publ. Norske Vid.-Akad. Oslo* **17,** 2, 17 pp., 1948.

2378. **Dörmann, H., Use of magnetic-tape recorders for registration of seismic waves over short distances** (in German), *Ann. Géophys.* **8,** 3, 286–293, 1952.

It is shown that it pays to use, for recording near earthquakes, seismographs with higher limiting frequencies than those used so far. The running cost may be kept low by the intermediate use of magnetic-tape recorders. After the evaluation and copying of each recorded earthquake, the tape can be wiped and used again. An instrument of this type is described, and first results are discussed. Application of the magnetic-tape recorder is recommended in geophysics wherever only short pieces of the records are used; that is, wherever rare events shall be recorded with high time resolution. From author's summary

Lubrication; Bearings; Wear

2379. **Deuker, E. A., and Wojtech, H., Radial flow of a viscous fluid between two neighboring disks. Theory of the air bearing. I. Case of a compressible fluid. II. Case of an incompressible fluid** (in French), *Rev. gén. Hyd.* **17,** 65, 66; 227–234, 285–294; Sept./Oct., Nov./Dec. 1951.

Authors are interested in forced lubrication through small orifices, near each of which the subject title is presumed a good approximation. Hydraulic theory is developed in collaboration with H. Kleinwaechter and H. Weiss for radially varying equation of state. Results are theoretically restricted to subsonic flow. Measurements agree satisfactorily with theoretical graphs.

A. Charnes, USA

2380. **Sims, R. B., Performance of hydrodynamically lubricated roll neck bearings,** *J. Iron Steel Inst.* **172,** part 4, 415–418, Dec. 1952.

Experiments are discussed which measure the magnitude of variation in film thickness of hydrodynamically lubricated roll neck bearings during the change in speed associated with acceleration and deceleration of the mill. The results indicate that the change in bearing film thickness is nearly linear with speed. This may account in part for the decrease (increase) in thickness of cold-rolled material during acceleration (deceleration). Engineering data and test results are given to substantiate the findings. J. J. Ryan, USA

2381. **McBrian, R., Diesel lubricated oil performance as related to the electron microscope,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-40, 6 pp., 19 figs.

Examination of new and used lubricating oils in electron microscope at magnifications of 45,000 and 6750 shows that a finely dispersed pattern is characteristic of a good detergent lubricating oil. Author expresses view that to secure freedom from excessive

wear a fine dispersion of additive plus contaminant of less than half-micron particle size must be maintained throughout the life of an engine.

An example is given of unexpected wear occurring as a result of use of a calcium-base additive of a type which had given good service for many years. All regular methods of analysis revealed nothing unusual, but electron microscope study showed that the additive had assumed a compact structure instead of being finely dispersed.

The suggestion is made that the electron microscope should be used to control all shipments of additive-type oils.

F. T. Barwell, Scotland

2382. Brophy, J. E., and Romans, J. B., The lubrication of gyroscopes, ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-51, 16 pp., 6 figs.

A great number of failures in gyroscope-type instruments are found to be due to bearing troubles. The choice of the lubricant is very important. The results of an investigation of some commercially available instrument gyroscopes are presented, established by measuring the rotor speed and rate of deceleration (by means of a G.R. strobatac), power input, bearing temperatures (thermocouples), bearing noise level and its frequency distribution (by means of a vibration pickup, a G.R. sound level meter, a G.R. sound analyzer, and a panoramic sonic analyzer). Problem seems to be very complicated, and much work has still to be done.

R. G. Boiten, Holland

2383. Nemeth, Z. N., Macks, E. F., and Anderson, W. J., Investigation of 75-millimeter-bore deep-groove ball bearings under radial load at high speeds. I. Oil-flow studies, *NACA TN* 2841, 30 pp., Dec. 1952.

Two inner-race-riding cage-type ball bearings were tested at speeds of from 4000 to 16,000 rpm (DN values of 0.3×10^6 to 1.2×10^6), loads of from 7 to 1113 lb, and oil flows of from 2 to 8 lb/min. Effect of oil flow on operating temperature was studied. Oil jet directed between inner race and cage was found to be most effective.

W. O. Richmond, Canada

2384. Ocvirk, F. W., Short-bearing approximation for full journal bearings, *NACA TN* 2808, 61 pp., Oct. 1952.

Author extends Michell-Cardullo theory to determine expressions giving applied load, attitude angle, film pressure, friction, and oil flow as functions of eccentricity ratio. Capacity number is formulated to allow curves for various e/d ratios (less than 1) to fall on single curve. Fair agreement with experimental data.

E. F. Macks, USA

Marine Engineering Problems

(See also Rev. 2211)

2385. Waeselynck, R., Theory of propeller thrust within the region of cavitation (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 365–382, 1952.

Using blade element and lattice theory, author first establishes an expression for propeller thrust under normal operating conditions, involving only one empirical characteristic coefficient. With the simplifying assumption that thrust is due entirely to blade dorsal depression when cavitation occurs, author then calculates the resulting thrust loss as compared to the theoretical value.

Results being in excellent agreement with experience, it is expected that author's calculation method will be of great practical value for predicting propeller thrust within the cavitation region.

P. Schwaar, Switzerland

2386. Jaeger, H. E., Approximate calculation of the rudder force and the moment on the rudder mechanism of a ship (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 399–426, 1952.

An extensive systematic survey of the available theory of forces and moments produced during maneuvering upon the ship and the rudder, including discussion of recent publications pertaining to rudder design, serves to point out the basic significance of the chordwise hydrodynamic pressure distribution of rudders. Author proposes the use of a master curve of pressure distribution quite in agreement with modern aerodynamic theory as a basis for design calculations. He takes into account the effect of ship's wake and propeller slip stream. His method is demonstrated by numerical calculations of pressure force and moment for balanced and Oertz rudders for single- and twin-screw versions of a given ship.

J. R. Weske, USA

2387. Tietjens, O. G., Method of using experimentally given functions as applied for deriving the maximum efficiency of ship propellers, *Mech. Engr., Bangalore, India* no. 1, 3–15, Oct. 1950.

Experimental data are generally used, either to check a theoretical functional relation or simply to obtain curves drawn through the experimental points. Author shows how to work such curves in a similar way as theoretical functions. Of course, it is of the utmost importance to draw the curves correctly.

The method is applied to the intricate practical problem of the choice of the propeller of highest efficiency in a given case of ship propulsion, including losses due to viscosity and cavitation. Only the method is explained. The sets of curves will be published elsewhere.

R. Spronck, Belgium

2388. Telfer, E. V., Further ship resistance similarity, *Trans. Instn. nav. Arch. Lond.* **93,** 4, 205–226, 1951.

Author takes up and emphasizes his earlier criticism [*TNECI*, 1928; *TINA*, 1927, 1949] of frictional formulas now admitted and recommended for ship-testing work. Schoenherr and Prandtl-Schlichting lines are characterized as untenable because of noneliminated wave-making and edge effect. It is claimed that geometrical similarity be established also in tests with frictional plates—a claim that is indispensable but not always fulfilled. The Froude plank tests, the surface finish, length-depth ratio effect, the Kempf pontoon tests, the Froude ship-model extrapolation, Froude rough plank tests, sand roughness correlation, sand and viscous roughness extrapolation, critical examination of the Lackenby and Schoenherr formulations are the items that are treated in the light of the extrapolation method. The general form of this method must be considered very adequate for illustrating the dependence of the resistance on the Froude and Reynolds numbers. The criticism it has met seems to be associated with the special form of extrapolator considered here. A firmer foundation of this form should be valuable.

E. Hogner, Sweden